

*Management of the California State Water Project - Appendix E*

**1998 Water Operations  
in the Sacramento-San Joaquin Delta**

*September 2002*

*Bulletin 132-99*



*Gray Davis, Governor  
Mary D. Nichols, Secretary for Resources  
Thomas M. Hannigan, Director*

*State of California  
The Resources Agency  
Department of Water Resources*

# Management of the California State Water Project

---

## Appendix E 1998 Water Operations in the Sacramento-San Joaquin Delta

Bulletin 132-99  
September 2002



Gray Davis, Governor, State of California  
Mary D. Nichols, Secretary for Resources, The Resources Agency  
Thomas M. Hannigan, Director, Department of Water Resources


## FOREWORD

---

This is the twenty-fourth edition of Appendix E, Bulletin 132, *Water Operations in the Sacramento-San Joaquin Delta*, an annual publication written for the State Water Project contractors, resource agencies, the State Water Resources Control Board, and other regulatory agencies. Appendix E documents SWP operations in the Sacramento-San Joaquin Delta, in addition to reporting on Delta water quality. SWP operations are modified to meet water quality standards and flow requirements, as well as environmental and other operational constraints.

The Sacramento-San Joaquin Delta has often been called the focal point of water resources development in California's Central Valley. The Delta is the collection point for State Water Project water delivery to the San Francisco Bay area, the San Joaquin Valley, and Southern California. Thus Appendix E is designed to document significant Delta events as well as to review overall performance of SWP Delta operations.

This report is based on the 1998 water year (October 1, 1997, through September 30, 1998), which was classified as wet for all beneficial uses under the SWRCB's 1995 Bay-Delta Plan criteria.



Thomas M. Hannigan  
Director

# Table of Contents

---

FOREWARD .....	iii
ACRONYMS AND ABBREVIATIONS .....	xi
I. SUMMARY .....	I
Water Supply Conditions .....	I
Water Supply Allocation - Actual Deliveries .....	I
State Water Project Operations .....	I
Lake Oroville and Feather River Operations .....	I
Delta Operations .....	2
Amended Winter-run Chinook Salmon and Delta Smelt Biological Opinions .....	3
Impact of Chinese Mitten Crabs .....	4
North Bay Aqueduct Operations .....	4
Delta Water Management .....	4
Delta Water Quality Standards .....	4
2. INTRODUCTION .....	7
The State Water Project .....	7
3. WATER SUPPLY CONDITIONS, ALLOCATIONS, AND DELIVERIES .....	11
Water Supply Conditions .....	11
Precipitation and Runoff .....	11
Snowpack .....	11
Reservoir Storage .....	12
Water Supply Forecast Indices .....	13
Allocations .....	14
Water Budget Process .....	14
Delivery Allocations .....	14
Deliveries .....	15
Annual Table A Deliveries to SWP Long-Term Contractors .....	15
Deliveries to Non-SWP Agencies .....	15
Floodwater .....	15
4. STATE WATER PROJECT OPERATIONS .....	19
State Water Project Operational Criteria .....	19
Feather River Water Operations .....	19
Lake Oroville Inflow, Releases, and Storage .....	22
Feather River Service Area Diversions .....	23
Effects of the Oroville-Thermalito Complex Water Operations on Feather and Sacramento River Flow .....	23
Augmentation .....	24
Reduction .....	24
SWP Delta Operations .....	26
Delta Cross Channel Gate Operations Criteria .....	26
Flow Standards .....	27
Vernalis Flow .....	27

Rio Vista Flow .....	28
Net Delta Outflow Index.....	30
Delta Exports.....	32
Real-time Monitoring Program .....	40
North Bay Aqueduct Operations .....	40
Delta Water Management.....	40
Interim South Delta Program .....	40
<b>5. DELTA WATER QUALITY STANDARDS .....</b>	<b>43</b>
Municipal and Industrial Standards.....	43
Agricultural Standards .....	47
Fish and Wildlife Standards .....	48
San Joaquin River Salinity Standard.....	50
Dissolved Oxygen Standard .....	50
Estuarine Habitat Protection Objective (X2).....	52
Suisun Marsh Protection Plan and Preservation Agreement .....	54
Bay-Delta Plan Brackish Tidal Marshes of Suisun Bay Narrative.....	56
Western Delta Municipal and Industrial Users Agreements.....	56
<b>6. OTHER DELTA AND SWP REPORTS .....</b>	<b>59</b>

# Figures

---

<b>Figure 2-1</b>	The State Water Project.....	9
<b>Figure 3-1</b>	Sacramento Valley water year hydrologic classification .....	16
<b>Figure 3-2</b>	San Joaquin Valley water year hydrologic classification .....	17
<b>Figure 4-1</b>	A map of the Oroville-Thermalito Complex .....	21
<b>Figure 4-2</b>	Lake Oroville inflow, releases, and storage during 1998.....	24
<b>Figure 4-3</b>	Effect of SWP operations on Feather River flow in 1998 .....	25
<b>Figure 4-4</b>	Sacramento River flows and Delta Cross Channel status during 1998 .....	28
<b>Figure 4-5</b>	San Joaquin River flow standard and operational criteria at Vernalis in 1998.....	29
<b>Figure 4-6</b>	Sacramento River wet-year flow minimums at Rio Vista in 1998 .....	31
<b>Figure 4-7</b>	Net Delta Outflow Index, 1998 .....	33
<b>Figure 4-8</b>	State Water Project Delta exports during 1998.....	34
<b>Figure 4-9</b>	SWP/CVP cumulative winter-run salmon loss and Delta exports .....	35
<b>Figure 4-10</b>	Expanded Delta smelt salvage estimates and export pumping.....	37
<b>Figure 4-11</b>	Combined Delta exports as percent of inflow diverted and Bay/Delta Plan objectives, 1998.....	38
<b>Figure 4-12</b>	South Delta barriers .....	42
<b>Figure 5-1</b>	The location of the SWRCB 1995 Bay-Delta water quality compliance stations in the Sacramento-San Joaquin Delta .....	44
<b>Figure 5-2</b>	Municipal and industrial water quality standards, 1998 .....	46
<b>Figure 5-3</b>	Agricultural standards in the western Delta, 1998 .....	48
<b>Figure 5-4</b>	Agricultural standards in the interior Delta, 1998 .....	49
<b>Figure 5-5</b>	San Joaquin River EC standards, 1998 .....	50
<b>Figure 5-6</b>	Dissolved oxygen concentration levels in the Stockton Ship Channel, 1998.....	52
<b>Figure 5-7</b>	Days of X2 (EC <2.64 mS/cm) compliance at Port Chicago, 1998.....	55

# Tables

---

<b>Table 3-1</b>	Sacramento Valley 40-30-30 Water Year Classification Index, Forecast and Actual Runoff, during the 1997-98 Water Year .....	14
<b>Table 4-1</b>	Institutional Framework for SWP Operations in the Sacramento-San Joaquin Delta during 1998.....	20
<b>Table 4-2</b>	Monthly Summary of the Oroville-Thermalito Complex Operations during 1998 (cfs) .....	22
<b>Table 4-3</b>	Lake Oroville Storage during Water Year 1997-98.....	23
<b>Table 4-4</b>	Effects of SWP Oroville Operations on Feather and Sacramento Rivers Flow during 1998 (cfs) .....	25
<b>Table 4-5</b>	Monthly Summary of Sacramento River Flows during 1998.....	27
<b>Table 4-6</b>	San Joaquin River Flow Objectives Measured at Vernalis during 1998.....	29
<b>Table 4-7</b>	Sacramento River Wet-Year Standards and Objectives at Rio Vista, 1998 .....	31
<b>Table 4-8</b>	Bay-Delta Plan and Amended D-I485 NDOI Flow Objectives, 1998.....	32
<b>Table 4-9</b>	Delta Exports at Tracy and Banks Pumping Plants during 1998 .....	35
<b>Table 4-10</b>	Bay-Delta Plan Export Limits Based on Percentage of Delta Inflow Diverted, 1998 .....	39
<b>Table 5-1</b>	Bay-Delta Plan and Amended D-I485 Wet Year Water Quality Standards for the Sacramento-San Joaquin Delta during 1998 .....	45
<b>Table 5-2</b>	Bay-Delta Standards Table A: Habitat Protection Outflow .....	53
<b>Table 5-3</b>	Determination of Habitat Protection Compliance during 1998 .....	54
<b>Table 5-4</b>	Amended D-I485 Suisun Marsh Salinity Standards in Effect during 1998.....	56

## State of California

Gray Davis, Governor

## The Resources Agency

Mary D. Nichols, Secretary for Resources

## Department of Water Resources

Thomas M. Hannigan, Director

Jonas Minton  
Deputy Director

Steve Macaulay  
Chief Deputy Director

Tom Glover  
Deputy Director

L. Lucinda Chipponeri  
Deputy Director for Legislation

Peggy Bernardy  
Chief Counsel

## Division of Operations and Maintenance

Stephen L. Kashiwada, Chief

Raphael A. Torres  
Gary G. Gravier  
Daniel F. Peterson  
Lawrence D. Joyce

Assistant to the Division Chief  
Chief, Water and Plant Engineering Office  
Chief, Environmental Assessment Branch  
Chief, Water Quality Section

### Written by

Tim P. Smith, Environmental Scientist

### Assisted by

Christine Erickson, Environmental Scientist

### Editorial and Production Service

Kay Mogavero, Supervisor, Technical Publications, State Water Project Analysis Office  
Cynthia Shepard, Research Writer, State Water Project Analysis Office  
Therese Tynan, Research Writer, State Water Project Analysis Office  
Maureen Reed, Research Writer, State Water Project Analysis Office

### Cover and Layout Design by

Cynthia Shepard, Research Writer, State Water Project Analysis Office

# California Water Commission

---

The California Water Commission serves as a policy advisory body to the Director of Water Resources on all California water resources matters. The citizen commission provides a water resources forum for the people of the State, acts as a liaison between the legislative and executive branches of State Government, and coordinates federal, State, and local water resources efforts.

Daniel M. Dooley, *Chair*, Visalia

Richard W. Atwater, La Canada

Ane D. Deister, Placerville

Rachel M. Dinno, Los Gatos

Martha G. Guzman, Sacramento

William J. Lyons, Jr. Modesto

Nancy Sutley, El Cerrito

Walter Yep, Piedmont

*Interim Executive Officer*

Peter D. Rabbon

*Staff Assistant*

Olene C. Chard

*Legal Counsel*

John R. Kramer

## Acronyms and Abbreviations

---

af	acre-feet	ISDP	Interim South Delta Program
AFRP	Anadromous Fish Restoration Program	maf	million acre feet
CALFED	State and federal resource agency program coordinating Bay-Delta management activity	MWD	Metropolitan Water District of Southern California
CCWA	Central Coast Water Authority	NBA	North Bay Aqueduct
CCWD	Contra Costa Water District	NDOI	Net Delta Outflow Index
CEQA	California Environmental Quality Act	NDWA	North Delta Water Agency
CESA	California Endangered Species Act	NEPA	National Environmental Policy Act
cfs	cubic feet per second	NMFS	National Marine Fisheries Service
CL	chloride concentration	PMI	Previous month's Eight River Index
COA	Coordinated Operation Agreement	RTM	real-time monitoring
CVP	Central Valley Project	SBA	South Bay Aqueduct
CVPIA	Central Valley Project Improvement Act (PL 102-575, Title 34)	SCVWD	Santa Clara Valley Water District
D-1485	SWRCB Water Right Decision 1485	SCWA	Solano County Water Agency
D-1630	SWRCB Water Right Decision 1630	SDIP	South Delta Improvement Program
D-1422	SWRCB Water Right Decision 1422	SDTBP	South Delta Temporary Barriers Project
Delta	Sacramento-San Joaquin Delta	SEW	Suisun Marsh Ecological Workgroup
DFG	Department of Fish and Game	SMPA	Suisun Marsh Protection Agreement
DO	Dissolved oxygen	SMPANT	Suisun Marsh Preservation Agreement Negotiation Team
DOI	Delta Outflow Index	SMSCG	Suisun Marsh Salinity Control gates
EC	Electrical conductivity (also referred to as specific conductance)	SRI	Sacramento River Index
EIR/EIS	Environmental impact report (State)/ environmental impact statement (federal)	SVUR	Sacramento Valley unimpaired runoff
EPA	Environmental Protection Agency	SWP	State Water Project
ESA	Endangered Species Act (federal)	SWRCB	State Water Resources Control Board
FERC	Federal Energy Regulatory Commission	taf	thousand acre-feet
FRSA	Feather River Service Area	USFWS	U.S. Fish and Wildlife Service
IEP	Interagency Ecological Program	USGS	U.S. Geological Survey
		WQCP	Water Quality Control Plan
		X2	location of 2 ppt. isohaline

# I. Summary

## **Water Supply Conditions**

The 1998 water year (October 1, 1997, through September 30, 1998) was classified as *wet* for all beneficial uses under the State Water Resources Control Board's 1995 Bay-Delta Plan criteria. It was affected by the presence of a strong El Niño sea surface temperature pattern in the eastern tropical Pacific that contributed to above-average precipitation in California, especially in the central and southern portions of the State. This was the fourth wet year in a row for Northern California.

## **Water Supply Allocation - Actual Deliveries**

---

In 1998, the SWP delivered over 2.75 maf of water to 27 long-term water contractors and 16 other agencies. SWP deliveries included 1.75 maf of long-term contractor supply, (including 123,019 af that was transferred between six SWP long-term contractors as permitted under the Monterey Agreement), 37,252 af of 1997 carryover water, 2,108 af of recreation/fish and wildlife water, and 1.0 maf of non-SWP long-term contractor supply.

In December 1997, the SWP water contractors were initially allocated only 50 percent of 1998 delivery requests. However, due to improving water conditions in January and February, the Department boosted allocations to 100 percent on March 13, 1998.

## **State Water Project Operations**

---

The 1998 SWP Delta operations were guided by the SWRCB's 1995 Bay-Delta Plan (adopted on

May 22, 1995) and by Decision 1485, as amended to conform to the plan in June 1995 (WR 95-6). The 1995 Bay-Delta Plan resulted from the establishment of the 1994 State-federal Bay/Delta Accord. The Accord arose from the need for a coordinated and comprehensive ecosystem approach to management of the Bay/Delta and was designed to balance proposed SWRCB's water quality standards and Endangered Species Act operational criteria imposed by National Marine Fisheries Service and U.S. Fish and Wildlife Service, with the need to provide water supply reliability. USFWS' Delta Smelt Biological Opinion and NMFS' Winter-run Chinook Salmon Opinion were revised on March 6 and May 17, 1995, respectively, to conform to the Bay/Delta Accord.

The Bay/Delta Accord was extended through 1998 to allow CALFED the additional time needed to complete its comprehensive plan for addressing the problems of the Bay-Delta Estuary.

The institutional framework guiding the SWP Delta operations during 1998 can be found in Chapter 4, Table 4-1.

## **Lake Oroville and Feather River Operations**

---

Lake Oroville began the 1998 water year with over 2.13 maf (60 percent capacity). Total inflow into the reservoir during water year 1998 totaled about 6.7 maf (approximately 150 percent of average). Lake Oroville's storage peak, reflecting its water supply for the dry season, occurred on June 28 when the storage reached 3,525,825 af (99 percent of capacity). The

carryover storage at the end of the water year (September 30, 1998) totaled 2.83 maf (122 percent of average).

Feather River Service Area contractors took water deliveries during every month of 1998 except February and March, for a total of 873 taf, and returned a calculated 216 taf as agricultural runoff (25 percent of the total diversion).

Releases from the Oroville-Thermalito Complex augment the flow of both the Feather and Sacramento Rivers while retention of storage reduces downstream river flow. Mean monthly river-flow was augmented for 5 months of 1998, from July through October and during December, with the highest augmentation occurring during August and September. River flow was reduced from January through June and again in November, with the greatest monthly reduction in January.

## Delta Operations

Operation of the SWP affects the Sacramento-San Joaquin Delta in many ways, including

- reduction of high winter and spring inflow,
- reduction of Delta outflows by diverting water for off-stream storage, or delivery to its contractors,
- augmentation of Sacramento River inflow and Delta outflow during the summer and early fall months, and
- alteration of the natural Delta circulation and outflow pattern.

During 1998, Delta water conditions, as defined under COA, can be in excess for the entire year. Excess flow days were further qualified by two outflow criteria that limit Delta export operations. These include one for fish salvage and another to limit export/inflow percentages. Neither of these two criteria were in effect during 1998.

The Bay-Delta Plan sets minimum monthly San Joaquin River flow objectives at Vernalis from February through June and in part of October. The flow minimums vary with water year type and the location of the X2 geographic isohaline, which can be located at either Chipps Island or



*A dredge barge docked along the Sacramento River*

Port Chicago. All San Joaquin River flow objectives or standards were met in 1998.

The Bay-Delta Plan requires closure of the Delta Cross Channel gates during the spring and fall, although the CALFED Operations Group allows some variations based on real-time fisheries monitoring. During 1998, the Delta Cross Channel gates were open for only 53 days, primarily from mid-July through early September. The gates closed from January 1, 1998, and remained closed through mid-July 1998 in response to abundant flows. The gates were closed on September 7, 1998, and remained closed through the balance of the year due to high flows and fishery concerns.

**Delta Outflow.** The Bay-Delta Plan contains a calculation of the Delta outflow called the Net Delta Outflow Index. Minimum monthly mean NDOI standards are set by the Bay-Delta Plan and range between 3,000 cfs and 7,100 cfs throughout the year; the amended D-1485 requires higher NDOIs than the Bay-Delta Plan (from January through June) and it also specifies even more rigid flow minimums for the periods of April 1-14 and May 16-31. The more stringent of these two is applied during those portions of the year when both standards are applicable.

The monthly mean NDOI never fell below 12,000 cfs during the entire 1998 calendar year. The year's highest mean monthly NDOI occurred in February with flows that averaged 244,739 cfs and contained the year's peak daily outflow of 320,363 cfs on February 8, 1998.

NDOI can also be used for alternate compliance with the estuarine habitat objective (X2) in lieu of a salinity-based standard. In 1998, the minimum 3-day running average NDOI standard was set at 29,200 cfs from February through June with X2 compliance being met at Port Chicago. All NDOI standards were easily met in 1998.

Mean monthly flow minimums at Rio Vista are set from September through December at levels ranging from 3,000 cfs to 4,500 cfs. The amended

D-1485 standards include year-round flow minimums (30-day running average) that vary from 1,000 cfs to 5,000 cfs. During compliance periods when both standards apply, the more stringent of the two is in effect. In 1998, Rio Vista mean monthly flow never fell below 13,042 cfs nor did the 30-day running average flows fall below 11,297 cfs, thus easily meeting all monthly and 30-day mean flow standards.

**Export/Inflow Ratio.** In 1998 the SWP exported 1.69 maf through Banks Pumping Plant, including 28,108 af for the Central Valley Project. In addition, CVP pumped a total of 14,799 af of SWP water at Tracy Pumping Plant. The Bay-Delta Plan includes a year round export ratio limit on Tracy and Banks Pumping Plants set as a percentage of Delta inflow. The standard for February through June can vary between 35 and 45 percent of Delta inflow, depending upon the Eight River Index, and is set at 65 percent from July through January.

Actual 1998 February through June export/inflow percentages averaged only 3 percent and the ratio dropped to only 2.4 percent during the April 15 through May 15 Anadromous Fish Restoration Program export restriction. From July through December the percent inflow diverted restriction rises to 65 percent, although maintenance operations and low demand limited combined exports during this period to only 22 percent.

### **Amended Winter-run Chinook Salmon and Delta Smelt Biological Opinions**

The amended Winter-run Chinook Salmon Biological Opinion included the concept of a warning (*yellow light condition*) when the combined salvage at Banks and Tracy Pumping Plants rose to 1 percent of the 1997 estimated out-migrating juvenile winter-run salmon population (1,383 smolts). The yellow light condition calls for a voluntary adjustment of operations in order to lower salvage numbers. A salvage level of 2 percent (2,766 smolts) triggers a *red light condition* and requires consultation with the Winter-run Chinook Salmon Monitoring Group.

On January 26, 1998, the yellow light warning condition was reached with the combined SWP/CVP loss exceeding 1,383 smolts and exports at Banks were halted. Banks' exports were already at a very low rate to accommodate a Delta fish experiment in the latter half of January. The 1998 winter-run sized salmon restriction period ended on May 31 with the combined loss totaling 1,536 smolts. This loss did not result in any further export restrictions.

The amended Delta Smelt Biological Opinion limits the combined incidental take of Delta smelt at SWP and CVP pumps. The combined limit of 400 fish is imposed year-round and is based on a 14-day running average of daily salvage. During 1998, the distribution and salvage of Delta smelt did not reach levels that required the curtailment of exports. The combined Delta smelt salvage totaled 988 for the year. Throughout the spring and early summer of 1998, Delta outflow was high and exports were relatively low, contributing to the movement of young Delta smelt away from the SWP and CVP export facilities and into the western Delta and Suisun Marsh.

### **Impact of Chinese Mitten Crabs**

An inundation of Chinese mitten crabs were entrained year-round at the SWP and CVP fish facilities, with almost a million entrained at the Tracy Fish Collection Facility alone. Fish salvage operations at the federal facility and Skinner Fish Facility were severely hampered by the large quantity of mitten crabs in the fish holding tanks and the transport trucks. Despite the hindrance to fish salvage, the mitten crab inundation did not have a significant impact on exports.

### **North Bay Aqueduct Operations**

The North Bay Aqueduct conveys Delta water pumped at Barker Slough in the north Delta to contractors in Napa and Solano Counties. In 1998, NBA delivered 35,125 af of SWP long-term contractor supply, of which 85 percent (29,766 af) went to Solano County Water Agency

and 15 percent to Napa County Flood Control and Water Conservation District (5,359 af).

## **Delta Water Management**

The Interim South Delta Program began in 1991 and during most years, ISDP installs four temporary south Delta barriers at locations on Middle River, Old River at Tracy, Old River at Head, and on Grant Line Canal. The barriers are designed to improve water levels and circulation for agricultural uses in the south Delta. Abundant San Joaquin River flows rendered the installation of any of the south Delta barriers unnecessary during 1998.

Generally, the Old River at Head barrier is installed in both spring and fall. The spring barrier prevents fish from straying into the inner Delta on their out-migration and the fall barrier prevents the straying of fish migrating upstream and helps alleviate low oxygen levels in the San Joaquin River. The other three barriers at Middle River, Old River near the Tracy Pumping Plant, and Grant Line Canal stabilize channel water levels for irrigation diversions during the agricultural season.

## **Delta Water Quality Standards**

Delta water quality is primarily regulated by salinity standards measured as either electrical conductivity or chloride concentration. These measurements reflect the impact of seawater intrusion and agricultural drainage as influenced by upstream inflows, reservoir releases, and exports. The 1995 Bay-Delta Plan contains additional water quality objectives for dissolved oxygen levels (6.0 mg/l) in specified stretches of the San Joaquin River. The Bay-Delta Plan also added an estuarine habitat protection objective using EC (2.64 mS/cm) or flow criterion of 11,400 cfs or 29,200 cfs depending on whether X2 is located at Chipps Island or Port Chicago, respectively. Narrative objectives for salmon protection and for protection of brackish tidal marshes of Suisun Bay that implicitly list water quality measures were also included.

Water quality objectives and standards are set to protect beneficial uses categorized as municipal and industrial, agricultural, and fish and wildlife uses. All municipal and industrial chloride maximums, as well as agricultural EC standards, were met at all sites during 1998. In addition, all fish and wildlife EC standards in the Delta and in the Suisun Marsh were met in 1998.

Average daily flows at Vernalis ranged from about 4,750 to 6,700 cfs from August through October. As a result, August 7 through October 20 monitoring at the 14 sites from Prisoner's Point to the Stockton Turning Basin revealed that all DO readings, at the surface and bottom, exceeded 5.0 mg/L.

Despite the high San Joaquin River inflows into the eastern Stockton Ship Channel, a DO depression (an area where DO levels were 6.0 mg/L or less) occurred in the central channel, from Columbia Cut to Fourteen Mile Slough, during August and early September. This area is west of Rough and Ready Island in

the eastern channel, where levels less than 5.0 mg/L have generally occurred.

By September 18, 1998, the late summer DO depression in the channel was eliminated. By October 20, 1998, DO levels in the channel rose to more than 8.0 mg/L, due to cooler water temperatures and sustained high San Joaquin River inflows into the channel.

The estuarine habitat objective (X2), in place from February through June, can be met with a specified number of days in which average EC is 2.64 mS/cm or less at either Chipps Island or Port Chicago. The number of days specified for average EC is based on the previous month's Eight River Index (PMI). The X2 objective can also be met with flow criteria, which is measured as a 3-day running average of NDOI; 11,400 cfs for Chipps Island and 29,200 cfs for Port Chicago. High Delta inflows met X2 compliance under all three criteria at Port Chicago from February through June 1998.



*A view of Jersey Island looking west up Dutch Slough from Bethel Island Road*

Channel salinity in the Suisun Marsh is managed through the operation of the Suisun Marsh Salinity Control Gates from October 1 through May 31.

During the tenth control season (October 1, 1997, through May 31, 1998), the control gates were operated from October 14 through December 3, 1997. Abundant precipitation lowered salinity throughout the marsh, making it unnecessary to operate the gates during the balance of the tenth control season. On February 3, 1998, the flashboards were removed as a result of flooding concerns in the marsh and they were

not reinstalled until the start of the eleventh control season in late September 1998.

Although the flashboards were in position, the control gates were not needed to meet salinity standards during the first half of the eleventh control season (October, November, and December 1998); however, the gates were operated intermittently during this period as part of a joint study to evaluate the use of modified flashboards to encourage the passage of adult salmon.

All Suisun Marsh salinity standards were met during 1998.

## 2. Introduction

Appendix E reports on the State Water Project's operation in the Sacramento-San Joaquin Delta as affected by upstream Oroville reservoir operations, water conditions, water demand, pumping operations, water quality standards, and environmental guidelines and initiatives.

### **The State Water Project**

The State Water Project is a system of reservoirs, power plants, pumping plants, and aqueducts that begins in Plumas County where three reservoirs make up the project's northernmost facilities—Antelope Lake, Frenchman Lake, and Lake Davis.

Downstream from these three reservoirs is Lake Oroville, the keystone of the SWP. Lake Oroville conserves water from the Feather River watershed. Contained by Oroville Dam, which is the tallest earth-fill dam in the western hemisphere, Lake Oroville is the project's largest storage facility, with a capacity of more than 3.5 maf. The map of the SWP (see Figure 2-1) identifies the major features of the SWP.

Water released from Lake Oroville flows down the Feather River and joins the Sacramento River near the town of Verona. The Sacramento River drains the northern portion of California's great Central Valley and ultimately flows into the Sacramento-San Joaquin Delta. The SWP, CVP, as well as local agencies, all divert water from the Delta.

Barker Slough Pumping Plant, located in the northern Delta, diverts water for delivery to Napa and Solano Counties via the North Bay

Aqueduct. In the southern Delta, near Byron, the SWP diverts water into Clifton Court Forebay where Banks Pumping Plant lifts water for delivery into Bethany Reservoir. South Bay Pumping Plant, located at Bethany Reservoir, delivers water through the South Bay Aqueduct to supply Alameda and Santa Clara Counties. Most of the water delivered into Bethany Reservoir from Banks Pumping Plant flows into the California Aqueduct for delivery to points south.

The 660-mile California Aqueduct winds along the west side of the San Joaquin Valley and transports water to O'Neill Forebay and San Luis Reservoir. The Department and Bureau of Reclamation jointly own the 2 maf San Luis Reservoir, which stores both SWP and CVP water.

SWP and CVP water released from San Luis Reservoir continues to flow south through the San Luis Canal. As the water flows through the San Joaquin Valley, it has to be raised more than 1,000 feet by four pumping plants before reaching the foot of the Tehachapi Mountains.

In the San Joaquin Valley near Kettleman City, the original Coastal Aqueduct stub (now called the *Coastal Branch*) serves agricultural areas west of the California Aqueduct. This branch has been extended to serve municipal and industrial water users in San Luis Obispo and Santa Barbara Counties.

The remaining water conveyed by the California Aqueduct is delivered to Southern California, but it must first cross the Tehachapi Mountains. The Edmonston Pumping Plant, located at the

foot of these mountains, raises the water 1,926 feet—the highest single lift of any pumping plant in the world. The water then flows into Antelope Valley, where the California Aqueduct divides into two branches—the East Branch and the West Branch.

The East Branch carries water through Antelope Valley into Silverwood Lake, located in the San Bernardino Mountains. From Silverwood Lake, the water continues flowing down the East Branch to Lake Perris, the southernmost SWP reservoir. The East Branch is currently being extended and will eventually carry water from

Devil Canyon Power Plant Afterbay to Cherry Valley, bringing water to Yucaipa, Calimesa, Beaumont, Banning, and other communities. Phase I is scheduled for completion in 2001, while Phase II is expected to be completed in 2015.

Water in the West Branch of the California Aqueduct flows through the Warne Power Plant into Pyramid Lake in Los Angeles County. From there it flows through the Los Angeles Tunnel and Castaic Power Plant into Castaic Lake, the terminus of the West Branch.



**Figure 2-1. The State Water Project**

# 3. Water Supply Conditions, Allocations, and Deliveries

## Water Supply Conditions

### Precipitation and Runoff

Water year 1998 (October 1, 1997, through September 30, 1998) was the fourth wet year in a row for Northern California. The year was affected by a strong El Niño sea surface temperature pattern in the eastern tropical Pacific Ocean. This contributed to above-average precipitation in California, especially in the central and southern portions of the State. The northern Sierra Nevada is the main source of the State's surface water supply, and its rainfall is indexed by averaging rain gauge totals at eight representative regional stations (8-Station Index). Northern Sierra rainfall during water year 1998 was 165 percent of average, substantially more than the 138 percent of average in water year 1997. Similarly, statewide rainfall in water year 1998 was 175 percent of average compared to 125 percent of average in water year 1997.

Sacramento Valley unimpaired runoff in water year 1998 was 31.4 maf or 173 percent of average and the San Joaquin Valley unimpaired runoff was 10.4 maf, representing 175 percent of average.

The water year began in October with near-normal precipitation; November's precipitation rose to 150 percent of average in the northern Sierra. After a slow start in December, with northern Sierra precipitation only 57 percent of average, the winter turned wet. In fact, January and February were extremely wet—January received 209 percent of average precipitation while February's northern Sierra precipitation totaled nearly three times average. Runoff from

the eight major rivers of the Sacramento and San Joaquin River basins (Eight River Index) from January through February totaled 12.6 maf (221 percent of average). This high runoff was much less than last year's flood runoff when the Eight River Index for January 1997 was 12.1 maf (48 percent of average) in just 1 month.

March and April also provided above-average precipitation in the northern Sierra (125 and 138 percent respectively), pushing the water year total at the end of April to 157 percent of average. May was cool and wet (more typical of March weather) with more than three and a half times the normal precipitation in the northern Sierra. A surprise storm in the upper Sacramento Valley near the end of May produced moderate flood flows on the Sacramento River and the latest occurring inundation of the Sutter and Yolo Bypasses ever observed in a flood season. June began wet and cool, but in the middle of the month the weather turned dry. June precipitation historically amounts to only 2 percent of the water year's total precipitation. However, June 1998 provided a respectable contribution to the water year's total with 2 inches, twice the average precipitation in the northern Sierra.

July and August were dry, producing scant precipitation right in line with the historical averages for these months. The water year ended with September providing above-average rainfall in the northern Sierra (111 percent of average).

### Snowpack

On average, the April to July snowmelt runoff from the snowpack of the western slope of the

Sierra-Cascade Range produces approximately 40 percent of California's annual usable water supply. Snowpack water content is reported in monthly Department snow survey bulletins from February 1 through May 1, and is used to predict the seasonal snowmelt runoff; this is known as the *April-July runoff forecast*. The forecast for the Sacramento Basin April-July runoff represents natural flow conditions (unaltered by upstream diversions) that would occur in the absence of constructed dams. The Sacramento River Basin April-July forecast for runoff was reported on May 1 as 153 percent of average (10.1 maf) and the actual April-July runoff totaled 182 percent average (12.5 maf). The San Joaquin River Basin April-July forecast on May 1 was 165 percent of average (6.1 maf), while the actual April-July runoff totaled 180 percent of average (7.1 maf).

The April 1 snowpack water content has historically reflected the April-July snowpack at or near its peak and is the most important predictor of seasonal snowmelt runoff. The 1998 snowpack was about 160 percent of normal statewide compared to only 75 percent on April 1, 1997. The snowmelt during April was less than normal with the help of late season storms in early April, which boosted the pack about 5 percent. However, the snowmelt began in earnest with the advent of warm weather that arrived mid-month, reducing the snow water content by about 10 percent. On May 1 the snowpack stood at 190 percent of average for that date. Frequent cold storms in May boosted the pack and low temperatures caused the snowmelt to nearly cease for about 2 weeks. June's cool start helped prevent a rapid snowmelt and on July 1 snow sensors still measured the snowpack at 25 percent of the April 1 accumulation. In most years the snow is essentially gone by this time.

### Reservoir Storage

At the beginning of water year 1998 (October 1, 1997) the carryover storage in the State's 155 major reservoirs stood at 23 maf (105 percent of average), about 3 maf less than the previous water year's start. At the same time, the major reservoirs of the SWP (Oroville, San Luis, and

the combined southern reservoirs) held 3.2 maf, about 1.1 maf less than the start of the water year 1997. Lake Oroville held about 2.1 maf, which was about 800 taf less than last water year's start and about 93 percent of average.

By January 31, 1998, abundant storms had pushed storage at the major SWP reservoirs to about 4.4 maf compared to 4.6 at this time in 1997. Lake Oroville storage had risen to about 2.65 maf compared to 2.9 maf on January 31, 1997. The State's share of San Luis Reservoir stood at 1.07 maf compared to about 1.1 maf at this time last year.

With precipitation above average each month from January through June (and, in the case of January and February, two and three times average) and a heavy snowpack in the mountains, the State's reservoirs received abundant inflows.



*Snowpack from the Sierra Nevada provides a major portion of California's spring and summer runoff.*

On May 31, 1998, the State's 155 major reservoirs contained about 33 maf, 114 percent of average and about 1.5 maf more than at the same time in 1997. The major SWP reservoirs held about 5.07 maf (121 percent of average) compared with about 4.59 maf on May 31 of last year. May 31, 1998, storage at Lake Oroville was about 3.3 maf compared to 3.2 maf at the same time last year. Late season storms coupled with a slower than average snowmelt pushed Lake Oroville's storage peak a little later into the year in 1998. Lake Oroville reached peak storage on June 28, 1998, at 3,525,895 af (99.6 percent of designed storage capacity). This storage peak represents the water storage for planned releases later in the year. The State's share at San Luis Reservoir stood at about 1.06 maf compared with 0.72 maf at this date in the previous year.

At the end of the water year, the State's 155 major reservoirs held nearly the maximum amount of storage that can be carried over and still meet winter flood control requirements. Storage totaled about 29.6 maf (136 percent of average) compared to 22.7 maf at the end of the 1997 water year. The SWP's major reservoirs contained about 4.39 maf in comparison to 3.2 maf at the same time last year; Lake Oroville contained about 2.83 maf (123 percent of average) compared to 2.14 maf at the end of water year 1997.

### Water Supply Forecast Indices

**Sacramento Valley.** The 1995 Bay-Delta Plan contains a water supply forecast index called the *Sacramento Valley 40-30-30 Index*, which is used in the water budget operations studies as an indicator of available water supply. This index largely replaced its predecessor, the Sacramento River Index. SWRCB uses the Sacramento Valley 40-30-30 Index for classifying types of water years and establishing a corresponding level of protection for the Sacramento-San Joaquin Delta (Figure 3-1, page 16). The water year classification system provides relative estimates of the potential water supply originating in a basin from rainfall, snowmelt runoff, groundwater accretion, and reservoir carryover storage.

The Sacramento Valley 40-30-30 Index incorporates seasonal differences in water contribution for the year and includes the addition of prior year conditions to establish a more reliable index of the water available for all beneficial uses. The factors (40-30-30) represent the percentage weight given to

- (1) the forecasted or observed current year's April through July Sacramento Valley unimpaired runoff,
- (2) the forecasted or observed current year's October through March Sacramento Valley unimpaired runoff, and
- (3) the previous year's index with a cap of 10.

The Sacramento Valley unimpaired runoff sums the major flows into the Sacramento River Basin; it is also known as the Sacramento River Index. The Sacramento Valley unimpaired runoff for the water year 1998 was 31.4 maf (173 percent of average).

On May 1, 1998, the Sacramento Valley 40-30-30 Index was forecast to be 12.4, resulting in the 1997-98 water year classification of wet for all beneficial uses (Table 3-1).

**San Joaquin Valley.** The 1995 Bay-Delta Plan also defines a San Joaquin Valley 60-20-20 Index that is calculated using methods similar to the Sacramento Valley 40-30-30 Index (Figure 3-2, page 17). The San Joaquin Valley 60-20-20 Index at the 75 percent exceedence level determines the water year type for the 1995 Bay-Delta Plan's Vernalis flow standards. The Sacramento Valley unimpaired runoff and a similar San Joaquin Valley unimpaired runoff total are summed to produce the Eight River Index. This index is used to determine the duration of the 1995 Bay-Delta Plan's habitat protection standard at Chipps Island and under specific conditions, at Port Chicago during February through June. The San Joaquin River unimpaired runoff for water year 1998 (including the Stanislaus, Tuolumne, Merced, and upper San Joaquin Rivers) was 10.4 maf (175 percent of average).

**Table 3-1.** Sacramento Valley 40-30-30 Water Year Classification Index, Forecast and Actual Runoff, during the 1997-98 Water Year (maf)

Date of Forecast	Sacramento Valley 40-30-30 Index Probable Exceedence %			Water Year Classification <sup>a</sup>	State Water Contractor Annual Table A Delivery (% of Request) <sup>b</sup>
	50%	90%	99%		
December 1, 1997	8.7	6.5		above normal	50%
January 1, 1998	8.4		5.7	above normal	60%
February 1, 1998	9.6		7.3	wet	80%
March 1, 1998	12.3		10.4	wet	100%
April 1, 1998	12.2		11.2	wet	100%
May 1, 1998	12.4		11.9	wet	100%
<hr/>					
Actual water year unimpaired runoff		31.4 maf (173% of average)			
April-July forecast snowmelt runoff					
May 1 forecast		10.1 maf (153% of average)			
Actual unimpaired snowmelt runoff		12.5 maf (182% of average)			

<sup>a</sup>Probability exceedence at the median level (50%) is used to determine Bay-Delta Plan water year class.

<sup>b</sup>Probability exceedence at the 90% level is used to forecast SWP water supply allocations in December and thereafter the 99% level is used.

On May 1, 1998, the San Joaquin Valley 60-20-20 Index for water year 1998 was forecast to be 5.1, resulting in the classification of the water year as wet.

## Allocations

### Water Budget Process

The SWP continues to satisfy long-term contractors' annual water requests within contractual agreements while assuring sufficient carryover storage to meet deliveries for Delta protection and emergencies in the following year. A balance between the State's water resources and contractor demand is met through the Water Budget Process.

### Delivery Allocations

The Water Budget Process makes annual forecasts based upon the following reservoir capacity and storage at Lake Oroville, San Luis Reservoir, Lake Del Valle, and the four southern reservoirs:

- hydrology projections for the current year and future precipitation, runoff (Sacramento Valley 40-30-30 Index), and groundwater accretion;
- operational constraints for environmental protection, recreation/fish and wildlife; and
- demands from contractors for agriculture, municipal and industrial uses, and requests from other agencies, including the Bureau.

The Water Budget is an iterative water delivery allocation process. Initial allocations for the coming year are made in December and are based on operations studies that assume 90 percent exceedence of historical water supply. Exceedence refers to the probability that unimpaired flow will exceed the historic water supply. Forecasts for the water year are updated at least monthly using operations studies that began in December.

SWP long-term water contractors were initially allocated only about 50 percent of their 1998 initial delivery of 3.34 maf requested in December of 1997. The final May 1 water supply forecast sets the approved Table A delivery amounts for

the water year. January's abundant rainfall allowed an increase in the approved Table A amount to about 60 percent on January 27, 1998. February's bountiful precipitation further boosted water supply confidence and allowed for another boost in the approved Table A amount to 80 percent. On March 13, 1998, the Department released its plans to deliver 100 percent of the water requested for 1998 by its 29 long-term SWP contractors, 3.19 maf.

## Deliveries

The Monterey Agreement was executed by the Department and the SWP long-term water contractors on December 1, 1994, to establish the principles for amending the Department's SWP water contracts with the long-term water contractors. The Agreement updated the management of the SWP by revising SWP long-term contracts and their administration. The Monterey Agreement contains 14 principles that reflect the Agreement's goals to increase reliability of existing water supplies, provide stronger financial management of the SWP, and increase water management flexibility by providing additional tools to local water agencies.

In 1998, the SWP delivered over 2.75 maf to 27 of its 29 long-term contractors and to 16 other agencies. This amount is 100 percent of the water requested by the SWP contractors in 1998 and is 900 taf less than delivered during 1997.

### Annual Table A Deliveries to SWP Long-Term Contractors

The 1998 total delivery to SWP long-term contractors was 1.75 maf (37,252 af of which were carryover water from 1997). This total delivery also included transfers among SWP long-term contractors, of which 123,019 af were delivered in 1998. A total of 17,180 af of 1997 water was delivered under Article 14(b) of the SWP long-term water supply contracts, as make-up for SWP outages. Also, during 1998, a total of 20,288 af of Article 21 water was delivered by the SWP.

### Deliveries to Non-SWP Agencies

During 1998, the Department conveyed 80,750 af of CVP water through SWP facilities. The following agencies and corporations received water through these agreements with the Bureau:

- Lower Tule River Irrigation District
- Pixley Irrigation District
- Musco Olive Products, Inc.
- Department of Fish and Game
- U.S. Department of Veteran Affairs
- U.S. Fish and Wildlife Service
- Westlands Water District

CVP water was also conveyed under SWRCB's WR 95-6, continued and modified by WR 98-9, which allows the use of Banks Pumping Plant as a joint point of diversion for water supply that CVP was unable to export due to fisheries restrictions.

Water rights water is another category of water transported through SWP facilities to long-term SWP contractors and other agencies according to terms of various local water right agreements. In 1998, 903,613 af of water in this category was delivered to the Feather River, South Bay, and Southern California areas.

### Floodwater

Occasionally, during wet years such as 1998, the Department accepts floodwater from the Kern River into the California Aqueduct through the Kern River Intertie—for delivery to water agencies under agreements or to help satisfy SWP delivery demands downstream of the intertie. This operation helps to alleviate flooding of farmlands within the Kern River Interests service and surrounding areas. During 1998, the Department accepted 188,088 af of floodwater through the Kern River Intertie into the California Aqueduct.

Year classification shall be determined by computation of the following equation:

$$\text{INDEX} = 0.4 * X + 0.3 * Y + 0.3 * Z$$

Where:      X    = Current year's April – July  
Sacramento Valley unimpaired runoff

              Y    = Current October – March  
Sacramento Valley unimpaired runoff

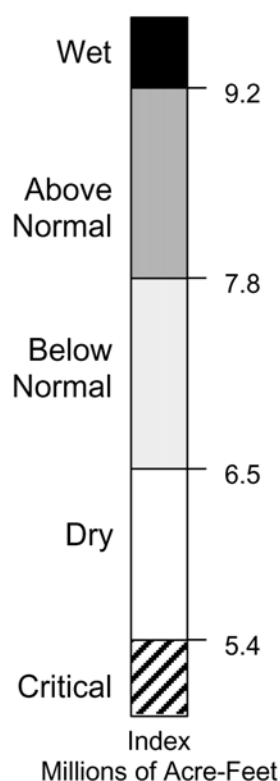
              Z    = Previous year's index<sup>1</sup>

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the

following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

<u>Classification</u>	<u>Index Millions of Acre-Feet (MAF)</u>
<b>Wet</b> .....	Equal to or greater than 9.2
<b>Above Normal</b> .....	Greater than 7.8 and less than 9.2
<b>Below Normal</b> .....	Equal to or less than 7.8 and greater than 6.5
<b>Dry</b> .....	Equal to or less than 6.5 and greater than 5.4
<b>Critical</b> .....	Equal to or less than 5.4

**YEAR TYPE <sup>2</sup>**  
All Years for All Objectives



<sup>1</sup> A cap of 10.0 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

<sup>2</sup> The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

**Figure 3-1. Sacramento Valley water year hydrologic classification**

Year classification shall be determined by computation of the following equation:

$$\text{INDEX} = 0.6 * X + 0.2 * Y + 0.2 * Z$$

Where:        X    = Current year's April – July  
                              San Joaquin Valley unimpaired runoff

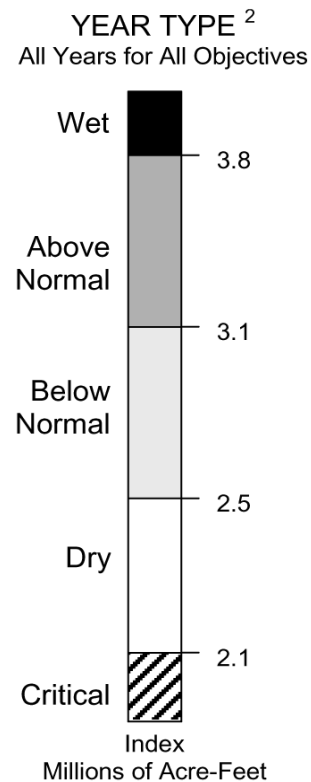
                  Y    = Current October – March  
                              San Joaquin Valley unimpaired runoff

                  Z    = Previous year's index<sup>1</sup>

The San Joaquin Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the

following locations: Stanislaus River, total flow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total flow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

<u>Classification</u>	<u>Index Millions of Acre-Feet (MAF)</u>
<b>Wet</b> .....	Equal to or greater than 3.8
<b>Above Normal</b> .....	Greater than 3.1 and less than 3.8
<b>Below Normal</b> .....	Equal to or less than 3.1 and greater than 2.5
<b>Dry</b> .....	Equal to or less than 2.5 and greater than 2.1
<b>Critical</b> .....	Equal to or less than 2.1



<sup>1</sup> A cap of 4.5 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

<sup>2</sup> The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

**Figure 3-2.** San Joaquin Valley water year hydrologic classification

## 4. State Water Project Operations

The water operations data used in this report are preliminary and may not agree exactly with final figures; however, they are appropriate for use in this report. References to years are calendar years, except where noted.

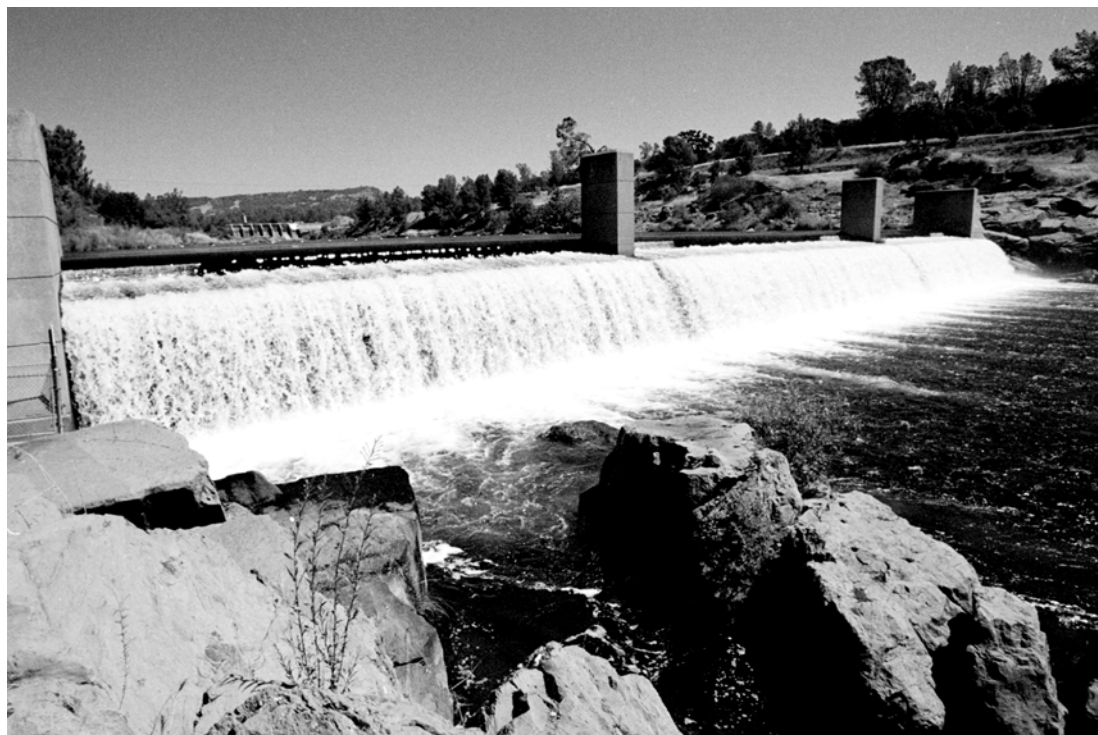
### State Water Project Operational Criteria

The Sacramento-San Joaquin Delta is an estuary and a navigable waterway subject to many State and federal laws that are designed to protect water quality, wetlands, anadromous and native fisheries, and migratory birds, in addition to threatened and endangered species. Table 4-1 provides a summary of the agreements, deci-

sions, opinions, and rules that make up the institutional framework for SWP operations in the Sacramento-San Joaquin Delta. These operational criteria, in combination, have a significant impact on water diversion from the Sacramento-San Joaquin Delta. They will not be discussed further in this report. For additional information on these criteria refer to Bulletin 132-98, Appendix E.

### Feather River Water Operations

Water stored in Lake Oroville (Figure 4-1) is released through Hyatt Power Plant into the Thermalito Diversion Pool, travels to the



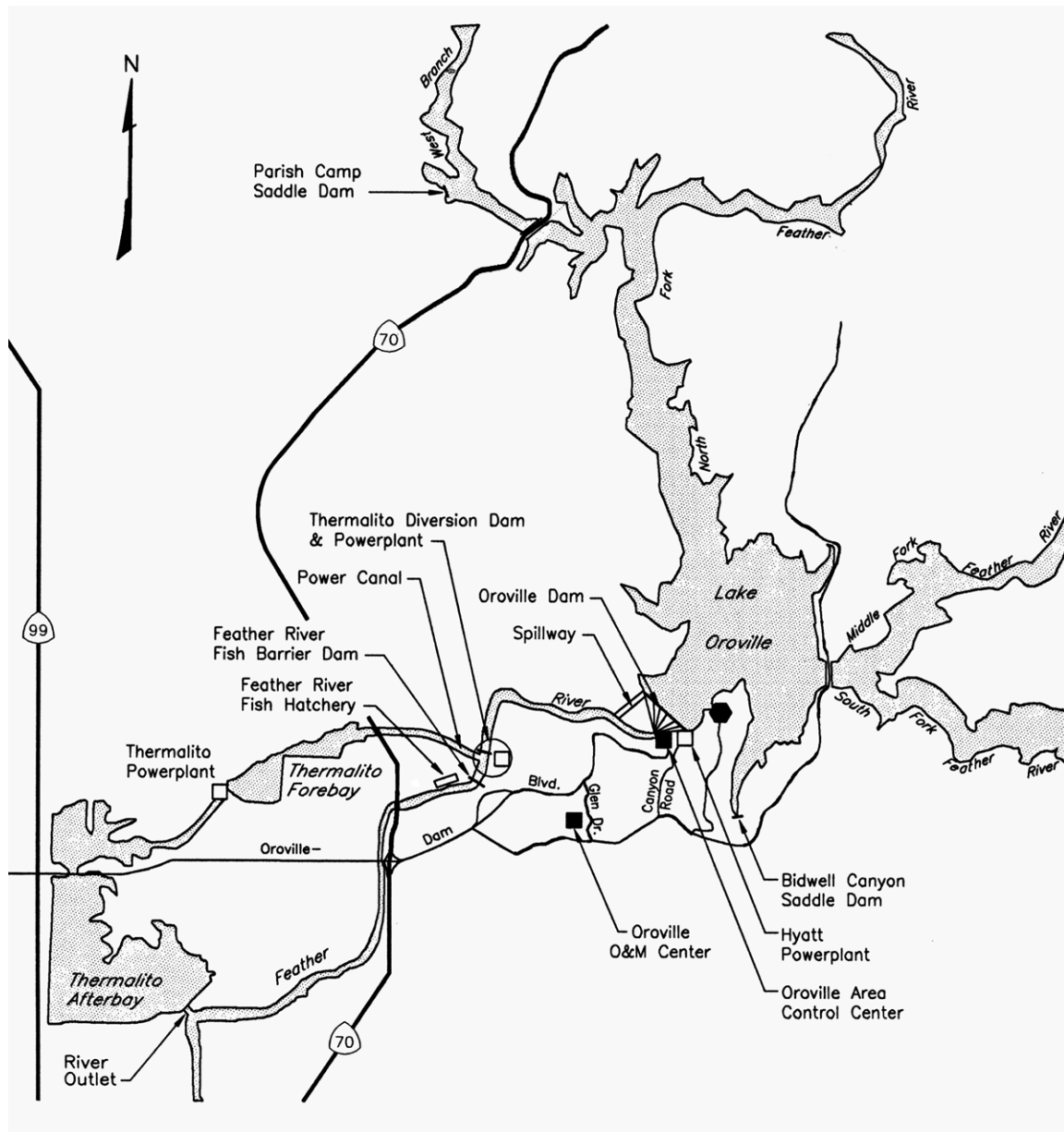
*The Feather River Fish Barrier Dam blocks fish from entering the Oroville-Thermalito Complex and diverts spawning salmon and trout into the fish ladder of the Feather River Fish Hatchery.*

**Table 4-1.** Institutional Framework for SWP Operations in the Sacramento-San Joaquin Delta during 1998

- 
- Agreement between the Department and DFG - "Concerning Operations of the Oroville Division of the SWP for the Management of Fish and Wildlife" - 7/67 and 8/83
  - SWRCB Water Right Decision 1485 - 8/78 modified by SWRCB Order 92-2 and SWRCB Order 92-8
  - U.S. Army Corps of Engineer's Section 10 permit and Public Notice 5820-A – 10/13/81. Permitted Operations of Banks Pumping Plant.
  - Agreement between the U.S.A. and State of California for Coordinated Operation of the SWP and CVP (COA) - 1986
  - Agreement between the Department and DFG to offset direct fish losses in relation to the Banks Pumping Plant, (Four Pumps Agreement) - 12/86
  - Suisun Marsh Preservation Agreement Among USBR, the Department, DFG, and WSRCB - 3/87
  - Central Valley Project Improvement Act (PL 102-575, Title 34) (CVPIA) - 9/92
  - NMFS Biological Opinion for Winter-run Salmon, long-term, 2/12/93. Amended 5/17/95 to conform to Bay/Delta Accord.
  - USFWS Formal Consultation on the 1994 Operation of the SWP and CVP: Effects on Delta Smelt (Long-term Biological Opinion) - 1/21/94, amended 3/06/95 to conform to the Bay/Delta Accord.
  - Framework Agreement between the Governor's Water Policy Council of the State of California and the Federal Ecosystem Directorate - 6/29/94
  - Monterey Agreement – Statement of Principles by the State Water Contractors and the State of California Department of Water Resources for Potential Amendments to the State Water Supply Contracts – 12/16/94
  - Principles For Agreement On Bay-Delta Standards Between The State Of California and The Federal Government (Bay-Delta Accord) - 12/15/94
  - Formal Consultation and Conference on Effects of Long-Term Operation of the Central Valley Project and State Water Project on the Threatened Delta Smelt, Delta Smelt Critical Habitat, and Proposed Threatened Sacramento Splittail, USFWS - 3/06/95
  - Water Quality Control Plan for the San Francisco Bay /Sacramento-San Joaquin Estuary (1995 Bay-Delta Plan) - 5/22/95
  - WR Order 95-6: Regarding Petition for Changes in Water Rights that Authorize Diversion and Use of Waters Affecting the San Francisco Bay/Sacramento-San Joaquin Delta Estuary - 6/8/95
  - WR 95-12: Order Validating the Issuance of Conditional Temporary Urgency Change Order Adding a Point of Re-diversion - 7/19/95
  - Principles For Agreement On Bay-Delta Standards Between The State Of California and The Federal Government (Bay-Delta Accord) extended for 1 year - 12/17/97
  - WR 98-9: Interim order that continues, as modified, the temporary terms and conditions set forth in WR 95-6 - 12/3/98
- 

Thermalito Diversion Dam then into the Thermalito Power Canal and the Thermalito Forebay. Water is released for electrical generation at the Thermalito Pumping-Generating Plant and then passes into the Thermalito Afterbay and is released to several local distribution systems for use in the Feather River Service Area or passes out to the Feather River through the Thermalito Afterbay river outlet.

Lake Oroville releases are routinely made for flood control, water supply, fish and wildlife protection, Delta water quality needs, and in response to unusual operational events. The 1983 Feather River Agreement with DFG sets minimum Feather River water flow rates and specifies maximum temperatures on the low flow channel of the Feather River.



**Figure 4-1. A map of the Oroville-Thermalito Complex**

Flows are also released from the Thermalito Diversion Dam to supply the low-flow channel of the Feather River and into a pipeline supplying the Feather River Fish Hatchery. The Feather River low-flow channel is the pre-SWP river channel and passes downstream of the hatchery, then merges with outflow from the Thermalito Afterbay river outlet, located 8.5 miles down river from the diversion dam.

The operation of Lake Oroville alters seasonal flows in the Feather River and subsequently in the Sacramento River and the Sacramento-San Joaquin Delta by retaining a portion of the winter and spring runoff for release during the summer and fall. Flood control operations at Oroville (October-June) dampen extreme flood peaks, thereby moderating flows entering the Delta (Table 4-2).

**Table 4-2.** Monthly Summary of the Oroville-Thermalito Complex Operations during 1998 (cfs)

Lake Oroville Inflow				Below Thermalito Outlet						Feather River Service Area	
Month				With SWP			Without SWP			Mean Diversion	Mean Daily Return Flow
	Average	Low Daily	High Daily	Average	Low Daily	High Daily	Average	Low Daily	High Daily		
Jan	13,376	2,937	34,669	6,442	1,759	13,999	13,180	2,316	34,435	255	59
Feb	18,367	9,745	52,172	17,642	6,000	25,000	18,367	9,745	52,172	0	0
Mar	14,529	7,172	46,287	13,047	6,250	25,000	14,529	7,172	46,287	0	0
April	12,281	9,548	16,864	8,799	6,000	14,000	12,262	9,548	16,864	27	7
May	14,120	8,731	19,819	8,754	4,261	10,881	12,894	6,558	19,207	1,696	471
June	14,495	9,052	18,663	9,349	7,451	12,260	12,876	6,673	17,447	1,950	331
July	5,808	3,696	9,290	6,108	5,334	8,327	3,327	1,206	6,896	2,830	350
Aug	3,818	2,854	4,725	6,304	5,481	7,483	1,714	627	3,178	2,640	536
Sept	3,361	1,654	4,571	6,868	4,782	9,118	2,961	1,417	4,167	1,199	799
Oct	2,509	642	4,458	3,830	2,775	6,361	2,033	360	3,703	1,040	535
Nov	5,660	2,998	22,775	2,308	2,046	2,784	4,735	1,917	22,131	1,202	276
Dec	7,770	4,401	28,629	10,548	3,698	17,184	7,147	3,751	28,092	809	186

Averages and daily values in this table are calculated or obtained from operational data found at [www.wmq.water.ca.gov/reports.htm](http://www.wmq.water.ca.gov/reports.htm).

The Department and the Bureau proportionally meet Sacramento Basin and Delta water needs through SWP and CVP operations as specified in a 1986 COA. The application of COA operational measures is conditioned by flows into the Delta. Operations of both projects seek to balance exports with in-basin and fish and wildlife needs. In 1998, sustained excess outflow conditions (as defined by COA) predominated for the entire year. Excess conditions allow greater flexibility in project operations; however, outflow standards can restrict exports during excess periods. A fish-related restriction applies when export pumping may impact endangered or threatened Delta fisheries. Exports are also restricted during excess flows to balance the export/inflow ratios within set objectives. A fisheries related restriction was in effect during approximately 19 percent of the designated *excess outflow* days (69 days) during 1998.

### Lake Oroville Inflow, Releases, and Storage

Lake Oroville began the 1998 water year with storage at 2.13 maf (60 percent capacity), about 570 taf less than at the same time in the 1997 water year. Lake Oroville inflow for the 1998 calendar year was 6.96 maf, only slightly more than the water year's total of 6.69 maf (150 percent of average). Because there was less than average precipitation in the northern Sierras in the first 3 months of the 1998 water year, higher winter inflows into Lake Oroville did not begin until about January 10, 1998. During the month of January, inflows totaled 820 taf and remained steady throughout February (1.02 maf), March (892 taf), April (730 taf), May (867 taf), and June (861 taf). In fact, inflows averaged over 27,700 af per day during this 6-month period.

Storage at Lake Oroville began a sharp increase during mid-January, but leveled off during February and most of March as encroachment of flood control space required spills of 207 taf and 118 taf, respectively. February contained the highest mean monthly inflow rate with more than 18,000 cfs per day, while March 24 was Oroville's highest daily inflow rate of 1998 with 46,287 cfs. Storage then began a steady climb in late March and continued until June 28, 1998, when Lake Oroville reached its storage peak of 3,525,825 af (approximately 99 percent of capacity).

On July 1, Lake Oroville storage began a slow, steady decline that continued until late November as inflows averaged less than 4,000 cfs during this period. October not only held the lowest monthly inflow rate, with an average of only 2,508 cfs per day, but also had the lowest daily inflow rate of 1998—a scant 642 cfs on October 24. The 1998 water year ended on September 30 with Lake Oroville's carryover storage at a bountiful 2.83 maf (122 percent of average) (Table 4-3, Figure 4-2).

**Table 4-3.** Lake Oroville Storage during Water Year 1997-98

Date	maf	Percent of Capacity <sup>a</sup>	Percent of Historic Average
October 1, 1997	2.13	60	92
February 1, 1998	2.68	76	116
March 1, 1998	2.71	77	105
April 1, 1998	2.81	79	100
May 1, 1998	3.04	86	103
WY peak on June 28 <sup>b</sup>	3.53	99.6	120
September 30, 1998	2.83	80	122

<sup>a</sup>Lake Oroville has a capacity of 3,537,580 af

<sup>b</sup>Peak daily storage during Water Year 1998 equaled 3,525,895 af

Flood control releases were made at Lake Oroville for 5 days in early December 1998 to counteract increased inflows brought about by late November storms.

The abundant water supply during 1998 easily met all Feather River flow and temperature criteria set in the 1983 DFG Feather River Agreement.

### Feather River Service Area Diversions

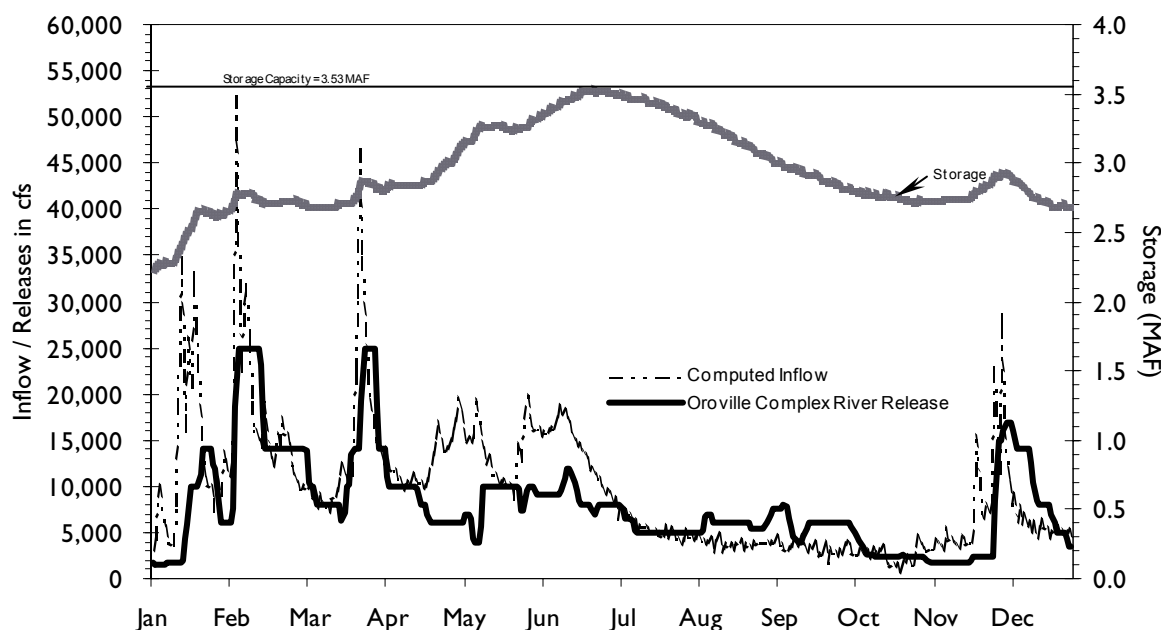
Diversions are made to FRSA from the Oroville-Thermalito Complex to local water agencies and to satisfy water right settlements that predate the construction of the SWP. The 1998 FRSA diversions totaled 873 taf and occurred during all months except February and March. FRSA returns water to the Feather River in the form of agricultural runoff, and in 1998 the calculated return totaled 216 taf, approximately 25 percent of the total diversion. The greatest amount of water was diverted during the months of May to August.

### Effects of the Oroville-Thermalito Complex Water Operations on Feather and Sacramento River Flow

The operation of the Oroville-Thermalito Complex impacts both the Feather and Sacramento Rivers. However, the effect of those releases on Sacramento River flow (below Freeport) is delayed by an approximate 2-day travel time.

The Department computes a *with SWP* (current project) and *without SWP* (pre-project) flow to describe the effects of Oroville-Thermalito Complex operation on both rivers and are defined below. Reservoir evaporative water losses are not included in these computations.

- (1) The sum of Oroville-Thermalito Complex releases to the Feather River plus the estimated FRSA return flows defines the *with-SWP* flow.
- (2) The pre-project *without-SWP* flow is calculated as Lake Oroville inflow minus deliveries to the FRSA (up to the limit of inflow), plus return flows from the FRSA.



**Figure 4-2.** Lake Oroville inflow, releases, and storage during 1998

- (3) The difference between the *with-SWP* and *without-SWP* flows is the approximated effect of SWP operations on Feather River flows.

Currently, most diversions to the FRSA in the summer months exceed calculated pre-project Feather River flows. Under pre-project conditions *without-SWP*, FRSA diversions from the Feather River could not have exceeded river flow. As a result, the *without-SWP* average monthly flow cannot be computed directly from Table 4-2 summary data.

### Augmentation

The flows in the Sacramento and Feather Rivers are considered *augmented* when the water released from the Oroville-Thermalito Complex exceeds the calculated pre-project flows. Feather River flows are often augmented as a result of Oroville-Thermalito releases executed for both evacuation of adequate flood control storage capacity in Lake Oroville, and to meet condi-

tions specified in the 1983 Feather River Agreement with DFG. Lake Oroville water is also released to meet Delta water quality and flow standards, ESA criteria, as well as SWP and non-SWP export needs at Banks Pumping Plant.

During 1998, the operations of the Oroville-Thermalito Complex augmented the flows in the Sacramento and Feather Rivers from July through October, in addition to December; the highest flow augmentation occurred during August and September.

### Reduction

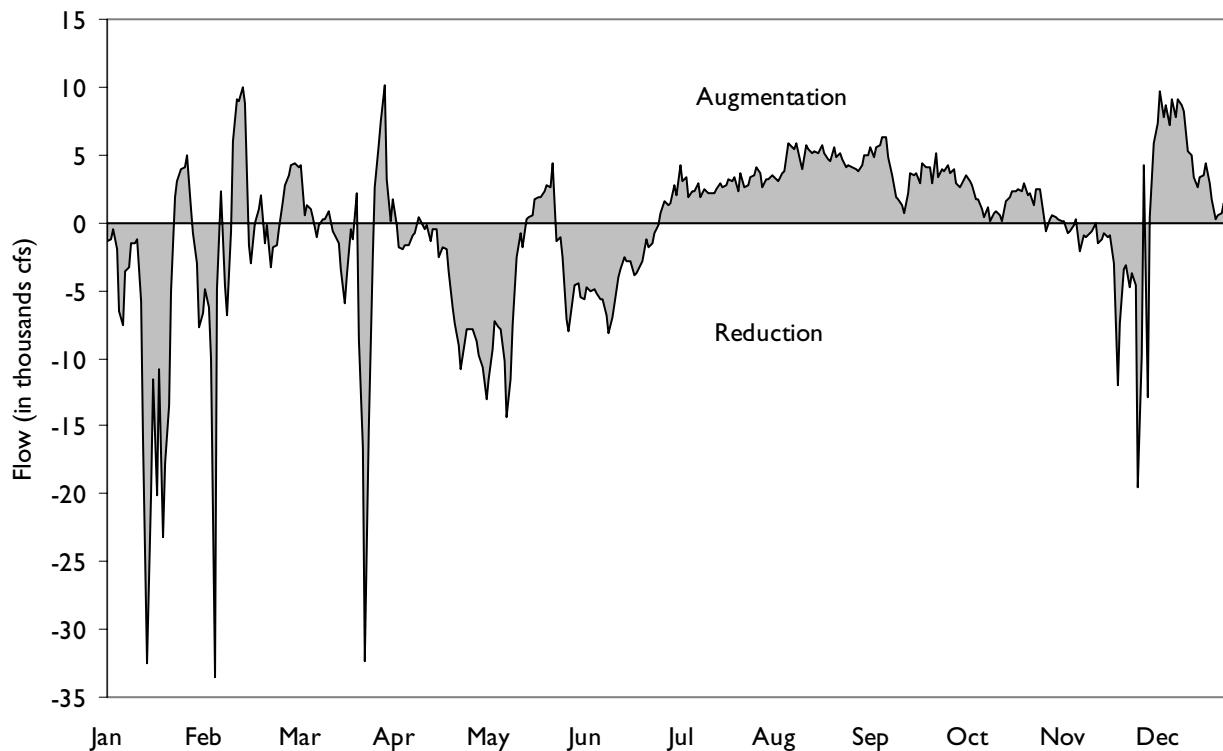
The flows in the Feather and Sacramento Rivers are considered *reduced* (designated by a negative value) when flow levels fall below pre-project conditions. Flows were reduced in 1998 by project operations during high inflow periods from January through June, and again in November. Monthly reductions were greatest during January when the Oroville-Thermalito Complex held back winter storm inflows (Table 4-4 and Figure 4-3).

**Table 4-4.** Effects of SWP Oroville Operations on Feather and Sacramento Rivers Flow during 1998 (cfs)<sup>a</sup>

	Months with Mean Augmentation				Months with Mean Reduction		
	Mean (+)	Minimum Augmentation	Maximum Augmentation		Mean (-)	Minimum Reduction	Maximum Reduction
July	2,675	1,291	4,298	January	-6,449	4,955	-32,565
August	4,539	2,538	5,846	February	-1,418	10,020	-33,589
September	3,905	626	6,361	March	-1,662	7,443	-32,287
October	2,059	73	4,271	April	-2,401	10,186	-10,864
December	2,661	-19,539	9,759	May	-4,404	4,308	-14,367
				June	-3,970	686	-8,189
				November	-1,631	541	-12,028

<sup>a</sup>Comparison of present river flows that would have occurred without Oroville Dam.

Note: Averages and daily values in this table are calculated or obtained from operational data found at [www.wm.wq.water.ca.gov/reports.htm](http://www.wm.wq.water.ca.gov/reports.htm).

**Figure 4-3.** Effect of SWP operations on Feather River flow in 1998

## SWP Delta Operations

The Sacramento-San Joaquin Delta is an estuary subject to sizable daily tidal fluctuations in flow and water levels. In fact, flows reverse direction twice daily throughout much of the Delta from a downstream to an upstream direction in response to the immense tidal actions of the Pacific Ocean. Delta flow patterns can be altered to some extent by SWP and CVP pumping. SWP's Banks Pumping Plant begins the export of Delta water from Clifton Court Forebay into the California Aqueduct and nearby South Bay Aqueduct. The federal Tracy Pumping Plant, located not far from Banks, begins exports through CVP's Delta-Mendota Canal. The SWP also exports water through its Barker Slough Pumping Plant into the North Bay Aqueduct in the northern Delta.

### Delta Cross Channel Gate Operations Criteria

Sacramento River flow at Walnut Grove in the northern Delta (between Freeport and Rio Vista) can be diminished by the diversion of water into

the Delta Cross Channel or into Georgiana Slough, a natural channel just downstream of the Cross Channel. The Delta Cross Channel is a gated diversion channel constructed and operated by the Bureau. The Cross Channel gates are usually closed whenever Sacramento River flow at Freeport exceeds approximately 25,000 cfs in an effort to reduce the flooding potential on the Mokelumne River and to prevent scour on the downstream side of the gate structure. However, the Delta Cross Channel gates may be opened when Delta water quality standards cannot be reasonably met by other means.

SWRCB's Bay-Delta Plan, as amended by WR 95-6, calls for closure of the Delta Cross Channel gates from February 1 until May 20, while from May 21 through June 15 the gates may be closed for a total of 14 days. During this period, the CALFED Operations Group determines timing and duration of gate closures. From the November-through-January period the gates may be closed for a total of 45 days, as determined by the CALFED Operations Group and based on real-time monitoring for the presence of winter-run salmon.



*The Delta Cross Channel gates, constructed by the Bureau in 1951, divert fresher Sacramento River water into the interior Delta towards the SWP and CVP export facilities.*

During 1998, the Delta Cross Channel gates were opened for only 53 days. The gates were closed during January with Freeport flows well over 25,000 cfs and remained closed through mid-July. The gates opened on July 17 and remained open until September 7, 1998. The gates remained closed for the rest of the year due to high river flows and fishery concerns (Table 4-5, Figure 4-4).

## Flow Standards

The Bay-Delta Plan also includes flow rate objectives for San Joaquin River at Vernalis, the Sacramento River at Rio Vista, and for Delta outflow using the Net Delta Outflow Index. RTM is a factor in determining the timing and duration of the San Joaquin River at Vernalis flow standard during April, May, and October. The 1998 Real-Time Monitoring Program sampled fish daily at seven Delta sites and covered a wider area on a bi-monthly basis from April 1 through June 30. The RTM Data Summary Team provided a synopsis of the monitoring results and recommendations to the CALFED Operations Group for making water project operational decisions. All flow objectives were met during 1998.

## Vernalis Flow

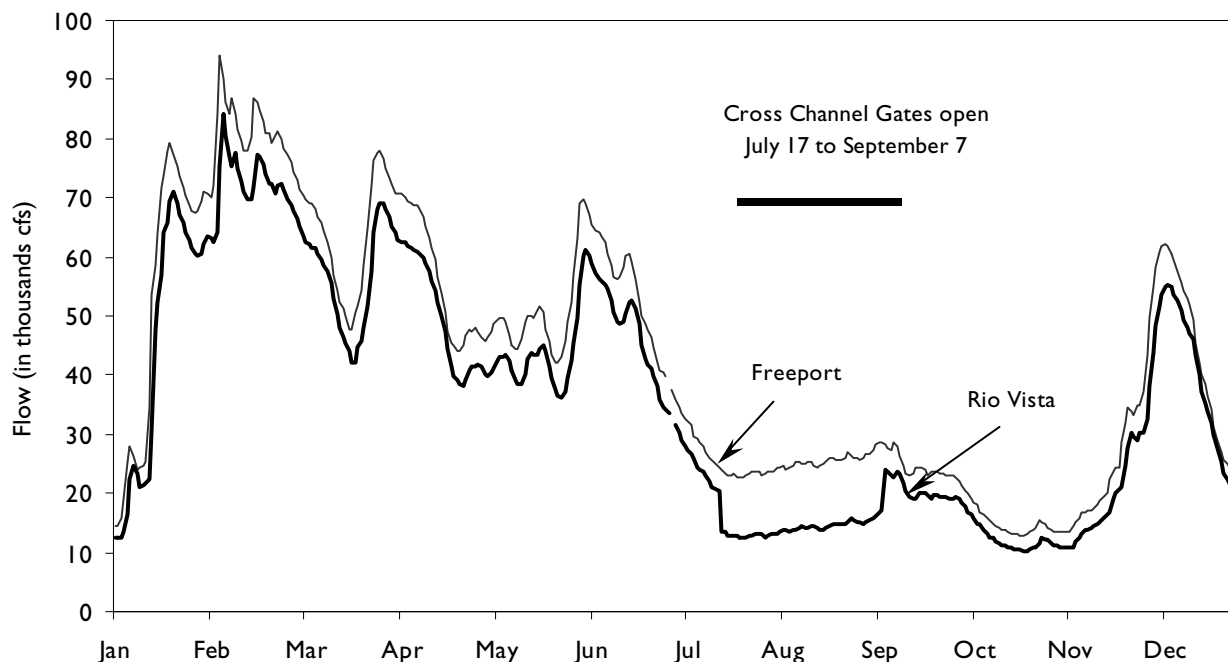
Vernalis is located at the southernmost boundary of the Delta near the confluence of the Stanislaus and San Joaquin Rivers and represents the San Joaquin River component of Delta inflow.

The Vernalis minimum monthly flow objective changes with water year type and is also dependent on whether the Habitat Protection Standard (X2) is met at either Chipps Island or further downstream at Port Chicago. The Vernalis water year type is determined by the San Joaquin Valley Water Year Hydrologic Classification at the 75 percent exceedence level. Due to favorable conditions in the 1998 water year, X2 compliance was attained at Port Chicago during February through June, requiring the higher base flow objective at Vernalis. During wet years, a base flow minimum is set at 3,420 cfs (monthly or partial monthly average) for the San Joaquin River at Vernalis from February 1-April 14 and May 16-June 30 when X2 is met at Port Chicago. An additional base flow minimum of 1,000 cfs applies during October with the addition of 28,000 af pulse/attraction

**Table 4-5.** Monthly Summary of Sacramento River Flows during 1998 (cfs)

	At Freeport			At Rio Vista		
	Mean	Low Daily	High Daily	Mean	Low Daily	High Daily
Jan	51,819	14,473	79,369	44,511	12,421	70,969
Feb	81,387	70,070	94,129	72,565	62,544	84,197
Mar	63,829	47,644	77,841	56,734	42,115	69,226
Apr	57,684	43,959	72,285	51,562	38,311	65,159
May	48,250	42,124	63,173	41,454	36,323	49,659
Jun	56,244	39,798	69,762	48,932	33,693	61,094
Jul	26,763	22,644	37,462	19,038	12,408	31,563
Aug	25,096	23,538	26,866	14,243	12,941	15,700
Sep	25,295	22,937	28,683	19,538	14,948	23,935
Oct	15,822	12,796	22,851	13,042	10,132	19,247
Nov	20,932	13,363	34,831	17,101	10,781	30,303
Dec	44,406	22,512	62,296	39,507	20,505	55,195

Note: Flows between Freeport and Rio Vista may be diminished by diversions through the Delta Cross Channel gates or through the Georgiana Slough. Monthly averages listed in this table will differ slightly from those found at [www.wm.wq.water.ca.gov/reports.htm](http://www.wm.wq.water.ca.gov/reports.htm) due to a 2-day time lag.



**Figure 4-4.** Sacramento River flows and Delta Cross Channel status during 1998

flow to increase San Joaquin River flow to 2,000 cfs. The CALFED Operations Group may also determine timing and duration of these flows based on real-time fisheries monitoring.

This base flow objective maintains a positive outflow through the central Delta while minimizing reverse flows conditions and fish entrainment at the export pumps. The 7-day average must not be less than 20 percent of period mean. San Joaquin River at Vernalis monthly flow averaged 28,048 cfs, 19,378 cfs, and 21,826 cfs for February, March, and the first half of April, respectively. Flows averaged 18,627 cfs during the latter half of May and were 18,023 cfs during June. October flows averaged only 5,715 cfs. All Vernalis base flow requirements were met in 1998.

The Bay/Delta Plan set a spring pulse flow objective at Vernalis, also conditioned by San Joaquin Valley 60-20-20 Index and the X2 compliance location. The spring pulse flows aid the transport of Delta smelt out of the southern and

central Delta to Suisun Bay during their critical spawning period. However, the pulse flow's timing and duration is based on RTM to coincide with fish migration in the San Joaquin River and its tributaries.

During the 1998 spring pulse flow period, April 15 to May 15, the wet year Vernalis flow is required to be 8,620 cfs, with X2 compliance at Port Chicago. Abundant precipitation pushed Vernalis flows to almost 25,000 cfs by April 15 and remained above 16,000 through May 15, easily surpassing the pulse flow requirement (Table 4-6, Figure 4-5).

### Rio Vista Flow

Sacramento River flow at Rio Vista is reduced by diversions through the Delta Cross Channel, through natural channels, and by Delta consumptive use, in addition to being opposed by tidal flow. The amended wet year D-1485 Rio Vista standards require year-round daily flow minimums at Rio Vista (calculated using a 30-day running average) to benefit migrating

**Table 4-6.** San Joaquin River Flow Objectives Measured at Vernalis during 1998 (cfs)

Period	Objectives and Flows	
	Monthly or Period Mean > <sup>a</sup>	Actual Monthly or Period Mean
<b>Base Flow<sup>b</sup></b>		
Feb	3,420 or 2,130	28,048
Mar	3,420 or 2,130	19,378
Apr 1-14	3,420 or 2,130	21,836
May 16-31	3,420 or 2,130	18,627
Jun	3,420 or 2,130	18,023
Oct <sup>c</sup>	2,000	5,715
<b>Pulse Flow (waived - see AFRP criteria below)</b>		
Apr 15 - May 15	8,620	19,381
<b>Vernalis Adaptive Management Program Experimental Period</b>		
VAMP provides alternate pulse flow objectives and combined export targets for the April 15-May 15 pulse flow period		
	Export Limit	Combined Exports
Apr 15 - May 15	3,000 <sup>d</sup>	1,791

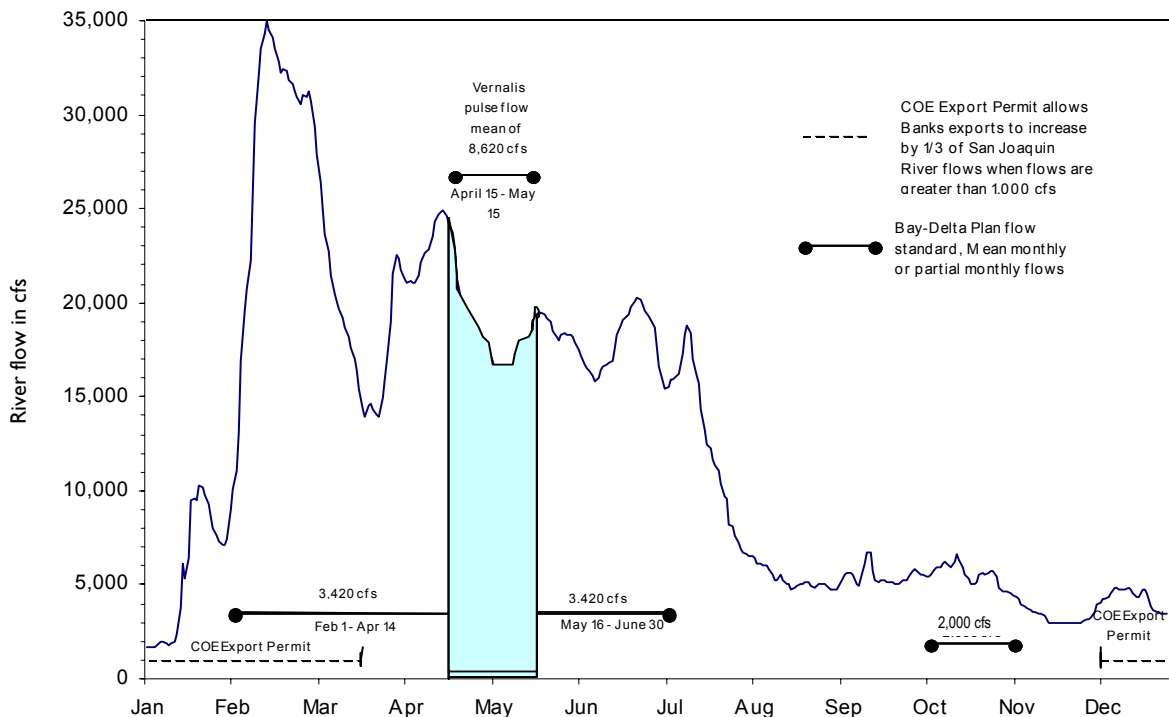
Additional base flow criteria:

<sup>a</sup>Higher flow objective was applied as the 2 ppt isohaline (X2) objective was west of Chipps Island.

<sup>b</sup>7-day running average shall not be less than 20% below the flow rate objective.

<sup>c</sup>1,000 cfs plus an additional 28,000 af pulse/attraction flow to bring up monthly average to 2,000 cfs; timing is determined by CALFED Operations Group.

<sup>d</sup>In 1998, high San Joaquin River flows prompted an alternate fisheries study associated with VAMP that limited combined exports to 3,000 cfs when Vernalis flows were in excess of 15,000 cfs.

**Figure 4-5.** San Joaquin River flow standard and operational criteria at Vernalis in 1998

salmon. They are set at 2,500 cfs in January; 3,000 cfs from February 1 to March 15; 5,000 cfs from March 16 to June 30; 3,000 cfs during July; 1,000 cfs in August; and 5,000 cfs from September through December.

The Bay-Delta Plan also includes Rio Vista mean-monthly flow minimums of 3,000 cfs, 4,000 cfs, and 4,500 cfs for September, October, and November-December, respectively. During these compliance periods, the 7-day running average daily mean cannot be more than 1,000 cfs below the required monthly average. During compliance periods when both standards apply, the more stringent of the two is in effect. During 1998, the Rio Vista mean monthly flow never fell below 13,042 cfs nor did daily values (30-day running mean) go below 11,900 cfs, easily meeting all flow standards and objectives at Rio Vista during 1998 (Table 4-7, Figure 4-6).

### Net Delta Outflow Index

Direct measurement of net Delta outflow is impractical because of huge tidal effects. However, since net outflow is one of the primary factors in controlling Delta water quality, the Net Delta Outflow Index was developed as part of the Bay/Delta Accord. NDOI is derived using flows from the Sacramento River, the San Joaquin River at Vernalis, the Yolo Bypass, the Eastside stream system (the Mokelumne, Cosumnes, and Calaveras Rivers), and discharges from the Sacramento Regional Wastewater Treatment Plant. Major Delta exports and an estimated in-Delta water use factor is then deducted from the cumulative inflow total to produce the index.

Both the Bay-Delta Plan and amended D-1485 include monthly NDOI flow minimums. Where NDOI objectives or standards overlap, the more



*The Sacramento and Liberty crane barges, docked near Rio Vista, are used for Delta levee maintenance.*

stringent of the two apply. During January, the minimum monthly flow is set at 6,000 cfs when PMI is greater than 800 taf. The wet year minimum monthly NDOI objectives set for July, August, September, and October are 8,000 cfs, 4,000 cfs, 3,000 cfs, and 4,000 cfs, respectively, and they rise to 4,500 cfs during November through December.

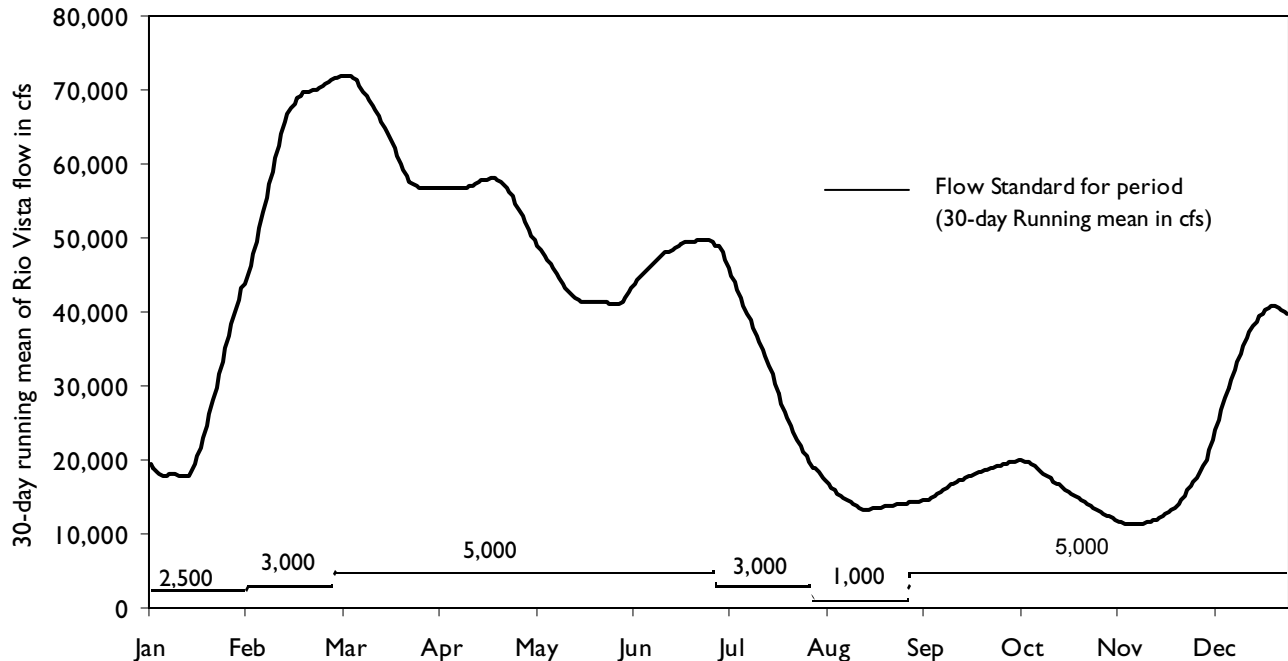
During February through June, the Bay-Delta Plan sets a minimum daily NDOI of 7,100 cfs calculated as a 3-day running average. The objective may also be met by a daily average or 14-day running average EC of 2.64 mS/cm at Collinsville for a specified number of days determined by PMI. The amended D-1485 standard sets more stringent monthly NDOIs from January through July. Monthly NDOI minimums during January are 6,600 cfs and rise to 10,000 cfs from February through May and in July. During June, the monthly NDOI standard rises to 14,000 cfs.

**Table 4-7.** Sacramento River Wet-Year Standards and Objectives at Rio Vista, 1998 (cfs)

Period	D-1485 Standards	Bay-Delta Plan Objectives	Period Values	
	Minimum daily 30-day running mean in period	Minimum mean monthly <sup>a</sup>	Lowest daily 30-day running mean in period	Mean monthly flow
Jan	2,500	—	17,773	—
Feb 1 - Mar 15	3,000	—	44,511	—
Mar 16 - Jun 30	5,000	—	41,038	—
Jul	3,000	—	20,443	—
Aug	1,000	—	13,347	—
Sep	5,000	3,000	14,243	19,538
Oct	5,000	4,000		13,042
Nov	5,000	4,500		17,101
Dec	5,000	4,500		39,507

<sup>a</sup>7-day mean not less than 1,000 cfs below monthly mean.

Note: During compliance periods when both standards or objectives apply, the more stringent of the two is in effect.

**Figure 4-6.** Sacramento River wet-year flow minimums at Rio Vista in 1998

Although January got off to a slow start, 1998 produced bountiful Delta outflows that easily exceeded all standards and objectives. NDOI drastically increased in mid-January; in fact, from January 17 through March 10, NDOI was sustained at above 100,000 cfs. This period included a 24-day span with NDOI above 200,000 cfs and within this span, a 5-day period of NDOI greater than 300,000 cfs (February 7 to 11).

Monthly average of NDOI remained above 20,000 cfs through August, dropping to 19,948 cfs in September. October had the lowest monthly NDOI of 12,264 cfs, while February recorded the highest at 244,739 cfs (Table 4-8, Figure 4-7).

### Delta Exports

The Sacramento-San Joaquin Delta is the major source of water for SWP deliveries south of the Delta. Inflow from the Kern River Intertie and

storm flows entering the California Aqueduct are also sources for SWP water south of the Delta. The SWP received a total of 188,048 af of floodwater from the Kern River Intertie during 1998.

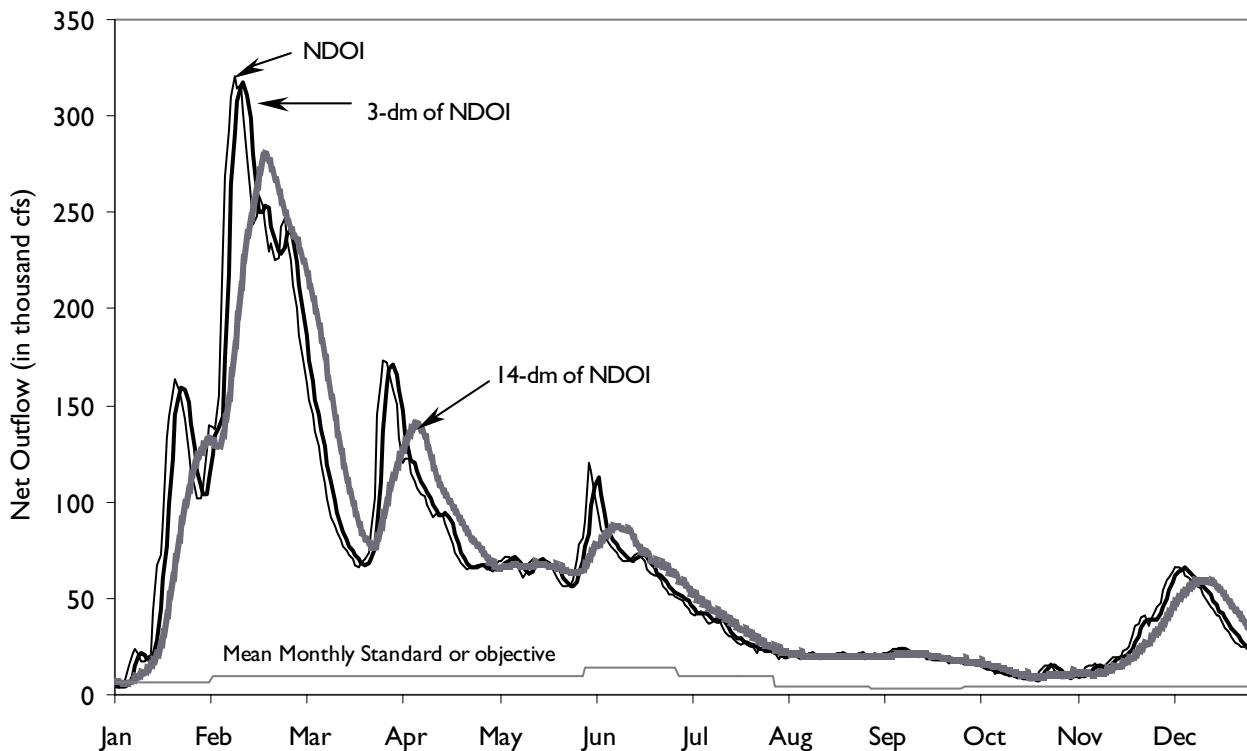
Banks Pumping Plant has the capacity to export at a rate of 10,670 cfs. However, a COE permit (Public Notice 5820A) limits the diversion rate to 6,680 cfs except from December 15 to March 15, when exports may increase by one-third of the San Joaquin River flow when its flow exceeds 1,000 cfs, up to 10,300 cfs (Aqueduct capacity south of Banks Pumping Plant). During 1998, San Joaquin River flow at Vernalis was in excess of 1,000 cfs during the entire year, allowing corresponding increases in the export rate. Export pumping rates are increased on weekends to take advantage of less costly off-peak electrical energy, producing sharp peaks in the export rate at about 7-day intervals (Figure 4-8).

**Table 4-8.** Bay-Delta Plan and Amended D-1485 NDOI Flow Objectives, 1998 (cfs)

Objectives and Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>NDOI - Bay-Delta</i>												
MM>	6,000 <sup>a</sup>						8,000	4,000	3,000	4,000	4,000	4,500
Min. daily 3-dm		7,100	7,100	7,100	7,100	7,100						
Min. daily 14-dm												
<i>NDOI - D-1485</i>												
MM>	6,600	10,000	10,000	10,000	10,000	14,000	10,000					
PM>				Apr 1-14 6,700	May 16-31 14,000							
<i>Actual Flows</i>												
MM	78,394	242,789	115,092	91,635	66,455	73,658	32,260	20,422	19,948	12,264	20,097	47,036
PM				Apr 1-14 112,082	May 16-31 65,688							
Min 3-dm or 14-dm		124,669	67,486	66,984	56,656	52,678						

<sup>a</sup>PMI >800 taf, January objective rises to 6,000 cfs

Note: During months with both Bay-Delta Plan objectives and amended D-1485 standards, the most stringent of the two applies. Shaded areas = objective, MM = mean month, 3-dm = 3-day mean; 14-dm = 14-day mean; PM = period mean



**Figure 4-7.** Net Delta Outflow Index, 1998

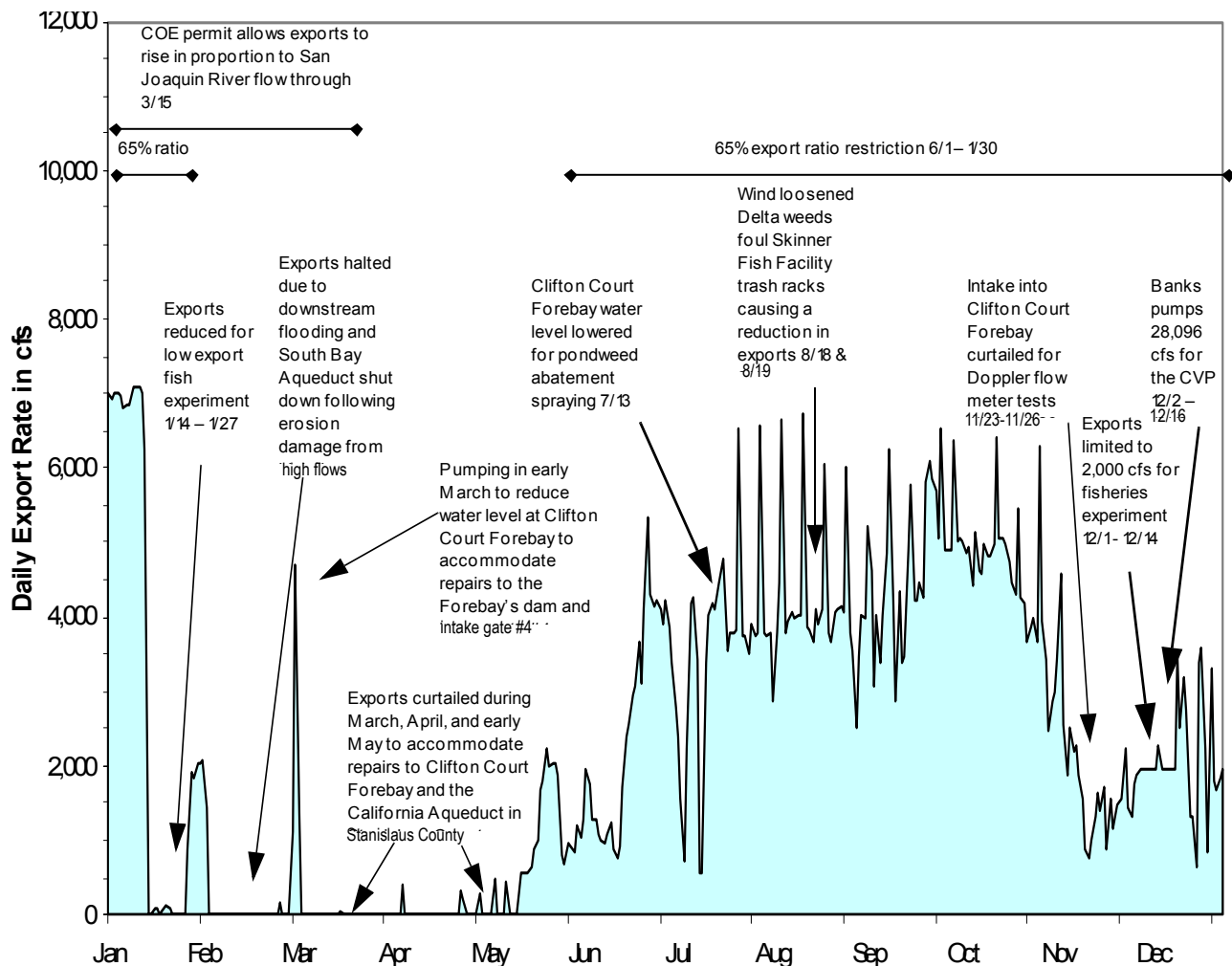
In 1998, the SWP diverted 1.69 maf at Banks Pumping Plant, about 67 percent of 1997 exports (2.54 maf), and 61 percent of all SWP deliveries, both SWP contractual and noncontractual (2.76 maf). Under the 1986 COA, SWP may export water for CVP later in the year to make up for exports not taken at its Tracy Pumping Plant under D-1485 fisheries limitations. WR 95-6 allowed CVP and SWP to use either project's pumping plants for exports to make up for export losses incurred for the protection of fisheries. These export exchanges may not jeopardize either of the projects' deliveries and require permission from CALFED Operations Group. During 1998, Banks Pumping Plant pumped 28,108 af of water for CVP (Table 4-9) and CVP pumped a total of 14,910 af for the SWP at Tracy Pumping Plant.

### Winter-run Chinook Salmon Export

**Restrictions.** The long-term Winter-run Chinook Salmon Biological Opinion, released in 1993 and amended in March 1995, set limits on

Delta exports based on the combined loss of winter-run-sized salmon smolt at the State and federal Delta export facilities, known as the *take level*. This opinion's incidental take statement invoked a yellow light warning condition when combined loss (Banks and Tracy Pumping Plants) reached 1,383 smolts, equivalent to 1 percent of the 1997 estimated out-migrating juvenile winter-run salmon population.

The projects voluntarily adjust export conditions to reduce loss numbers when yellow light conditions are reached. Loss levels at 2 percent or 2,766 fish trigger a red light condition that initiates consultation with the Winter-run Chinook Salmon Monitoring Group. These yellow and red light export restrictions were in effect from October 1997 through May 1998, the predominant period of salmon migration. The fish loss or estimated take is a calculated value derived from combined salvage numbers at SWP and CVP fish facilities expanded by empirically determined factors including sampling duration, salvage efficiency, forebay predation, and losses due to handling and hauling.



**Figure 4-8.** State Water Project Delta exports during 1998 (annotated with significant factors affecting exports)

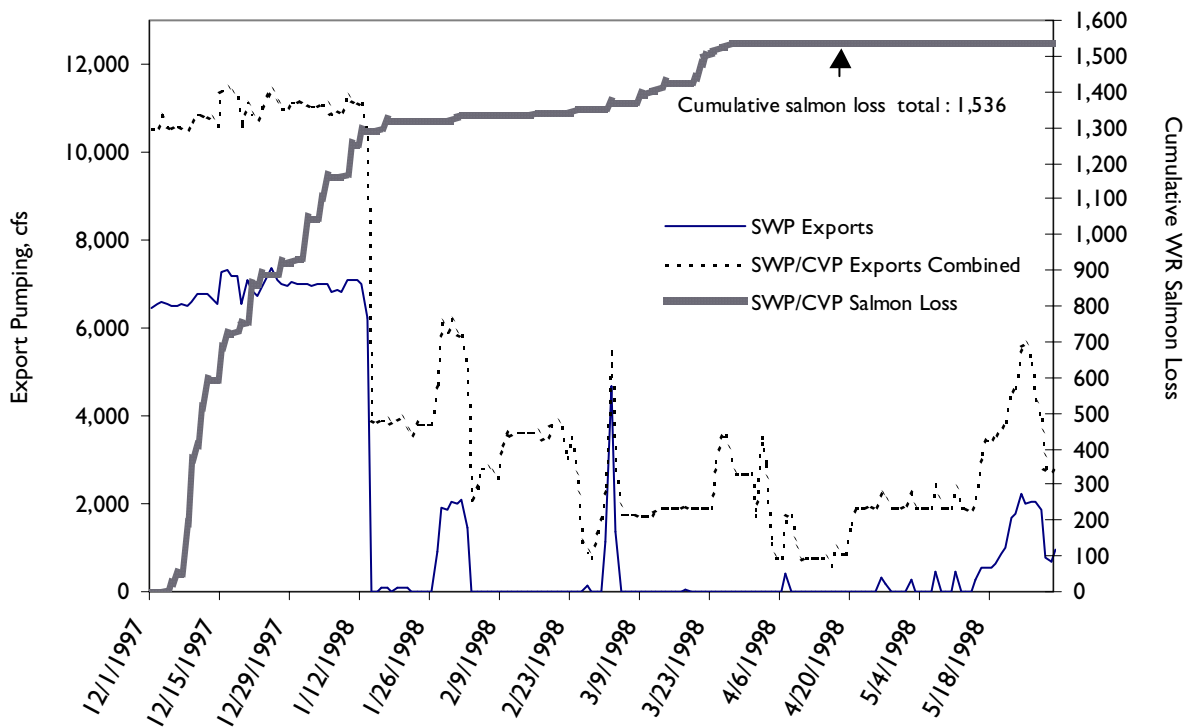
In January 1998, the yellow light warning condition of 1,383 smolts was reached for winter-run salmon and exports at Banks Pumping Plant were halted. Exports were already at a very low rate due to a Delta fisheries experiment conducted between January 14 and 27. By the end of the 1998 winter-run salmon restriction period on May 31, the combined loss at the SWP and CVP facilities combined totaled 1,536 smolts (Figure 4-9).

**Delta Smelt Export Restrictions.** The amended Delta Smelt Biological Opinion established a year-round Delta smelt salvage action

level of 400 fish (14-day running mean of daily salvage), known as the *yellow light* level that triggers informal consultation with USFWS, the Bureau, DFG, and the Department. The combined salvage is the sum of Delta smelt salvaged at CVP's Tracy and SWP's Banks Pumping Plants, expanded by other factors similar to those used in the winter-run salmon calculation. The red light level varies with the month and water year type — below-normal water years generally having a higher red light level than the level set for above-normal water years. Reaching the red light level triggers formal

**Table 4-9.** Delta Exports at Tracy and Banks Pumping Plants during 1998

Month	SWP (cfs)	Banks Export For SWP (af)	Banks Export For CVP (af)	Total Banks Exports (af)	Total Tracy Exports (af)	SWP/CVP Combined Exports (af)
Jan	3,197	196,572	0	196,572	243,014	439,586
Feb	131	7,285	0	7,285	164,144	171,429
Mar	233	14,309	0	14,309	126,792	141,101
Apr	31	1,871	0	1,871	86,007	87,878
May	726	43,225	0	43,225	142,654	185,879
Jun	1,970	128,947	0	128,947	170,308	299,255
Jul	3,471	213,401	0	213,401	249,614	463,015
Aug	4,296	264,172	0	264,172	268,748	532,920
Sep	4,474	266,203	0	266,203	259,261	525,464
Oct	4,787	280,894	0	294,812	255,695	550,507
Nov	2,176	129,489	0	129,489	127,028	256,517
Dec	2,082	113,836	14,190	128,026	2,052	130,078
<b>Total</b>	-----	<b>1,660,204</b>	<b>14,190</b>	<b>1,688,312</b>	<b>2,095,317</b>	<b>3,783,629</b>

**Figure 4-9.** SWP/CVP cumulative winter-run salmon loss and Delta exports, December 1, 1997, to May 31, 1998



*Remnants of pier in the Mokelumne River*

consultation with the fisheries agencies to determine whether additional actions are necessary to avoid jeopardizing the species.

In 1998, the distribution and salvage of Delta smelt did not reach levels that required curtailment of SWP exports. The combined Delta smelt salvage for 1998 totaled 988 fish and the running 14-day mean of smelt salvage never rose above 29 fish. Throughout the early spring and summer, Delta outflow was high and exports were relatively low, which contributed to the movement of young Delta smelt away from the SWP and CVP export facilities and into the western Delta and Suisun Bay (Figure 4-10).

**Bay-Delta Plan Export Restrictions.** The 1995 Bay-Delta Plan contains a year-round export objective that conditions exports by setting them in proportion to Delta inflow. This percent inflow diverted objective varies by month and is conditioned by PMI. The 1998 combined CVP/SWP export objective was set at 35 percent of Delta inflow from February

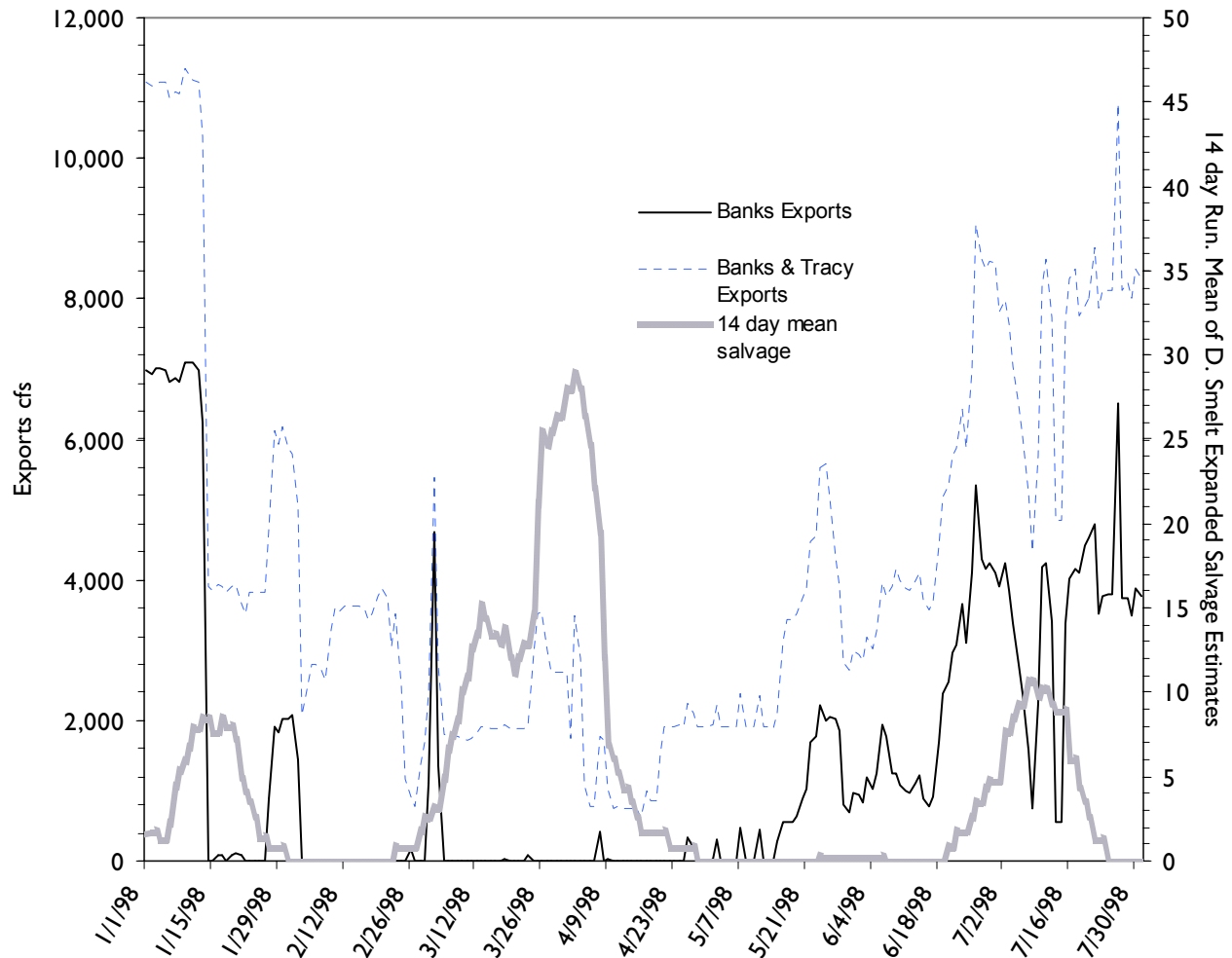
through June, and 65 percent during January and the remainder of the year.

The actual export amount is calculated using the combined inflow rate for Clifton Court Forebay (excluding Byron-Bethany Irrigation District diversions from Clifton Court Forebay) added to the Tracy Pumping Plant diversion. The percent inflow diverted is then determined by dividing this sum by the total inflow into the Delta. The percent inflow diverted objective is calculated using a 3-day running average of exports and a 14-day running average of Delta inflow. This changes during periods when CVP or SWP exports are dependent upon storage withdrawals from upstream reservoirs, in which case both export rate and Delta inflow are calculated as 3-day running averages.

During January 1998, downstream demands pushed exports in the first half of the month. From January 14 through 26, a fisheries experiment that required low export rates held combined exports to 3,800 cfs and SWP exports to less than 360 cfs. The resulting percent inflow diverted average for January was only 26 percent when as much as 65 percent is allowed for the month.

During the more restrictive February to June period (35 percent objective), the percent of inflow diverted averaged only 3 percent, because exports at Banks Pumping Plant were halted during much of February, March, April, and early May. Downstream flood flows and the near-full condition of the San Luis Reservoir limited February's export total at Banks to only 7.3 taf. Also during February, a portion of the South Bay Aqueduct pipeline was shut down to repair erosion damage caused by high flows in adjacent creeks. During March, repairs to Clifton Court Forebay kept its intake gates closed for the entire month. Pumping at Banks during the first week of March enabled Clifton Court Forebay's elevation to be drawn down to 2.5 feet below sea level in order to accommodate repairs to the forebay dam and Intake Gate 4.

In early April, projects to repair seepage problems along the California Aqueduct in



**Figure 4-10.** Expanded Delta smelt salvage estimates and export pumping, January to July, 1998

Stanislaus County at Mile 52.4 and Mile 55 were initiated. These repair projects were undertaken at a time when south State water demands could be easily met with storage releases from San Luis Reservoir. This resulted in very low exports at Banks throughout April and into the first half of May.

SWRCB approved a joint point of diversion in early March to allow the export of SWP water at Tracy Pumping Plant while repairs were conducted at Clifton Court Forebay and on the portions of the California Aqueduct mentioned above. From March 24 through April 1, 1998, CVP pumped a total of 14,220 af of SWP water at Tracy Pumping Plant. An additional 579 af of SWP was exported in December.

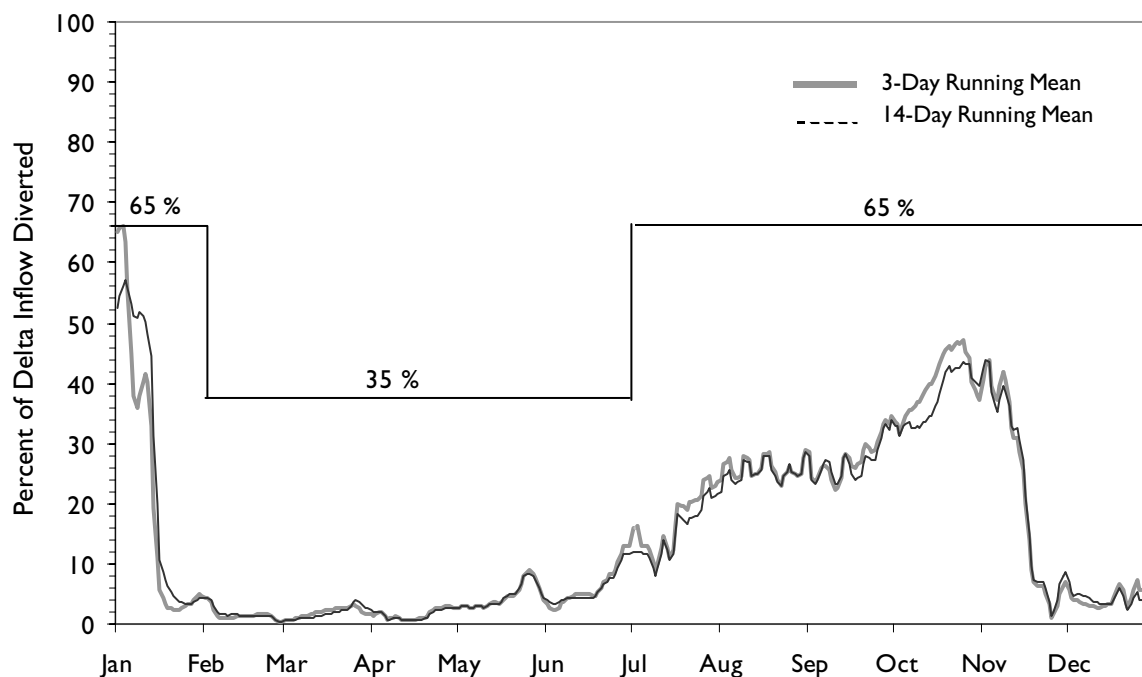
The Bay-Delta Plan applies an additional export limitation during the spring pulse flow period on the San Joaquin River. It limits combined exports from April 15 through May 15 to 1,500 cfs or 100 percent of the 3-day average of the San Joaquin River flow at Vernalis, whichever is greater. During the 1998 spring pulse flow export period, San Joaquin River flow was about 25,000 cfs and the percentage of inflow diverted dropped to 2.4 percent. Most water exports occurred at Tracy Pumping Plant during the spring pulse flow period and were sustained at a rate of about 1,900 cfs. Pumping at Banks Pumping Plant only occurred on 7 days during the 30-day pulse flow period and averaged only 289 cfs.

From July through December, the Bay-Delta Plan allows combined exports to increase to 65 percent of Delta inflow; however, in 1998, exports averaged only 22 percent during this period because of maintenance operations and low water demand. On July 13, Clifton Court Forebay was lowered to 1.5 feet below sea level for a 36-hour period for pondweed abatement. This limited exports at Banks to only the ability to supply South Bay contractors. Also, from June 24 through August 4, Banks exports were slightly constrained due to a problem with an effluent pump at Skinner Fish Facility. In 1998, Banks' exports were highest in October, averaging 4,787 cfs per day and 37.4 percent of Delta inflow. In December 1998, Banks' exports were voluntarily reduced to 2,000 cfs; however, due to low contractor demands and a high storage level at San Luis Reservoir, there were no water supply impacts. All Bay-Delta Plan, amended D-1485, ESA-related, and AFRP export criteria were met during 1998 (Figure 4-11, and Tables 4-8 and 4-10).

### Vernalis Adaptive Management Plan.

VAMP grew out of the San Joaquin River Agreement, a cooperative effort to address fishery conditions on the lower San Joaquin River in compliance with State and federal requirements. The San Joaquin River Agreement settles legal challenges to the 1995 Bay-Delta Plan by its water right holders. VAMP is a federal/State study designed to examine the effect of flow and export rates on the salmon fisheries in the lower San Joaquin River. From April 15 to May 31, 1998, a series of studies were conducted to assess salmon smolt survival under conditions of high flow and low exports. In June 1998, the Department signed a Statement of Support encouraging SWRCB to implement VAMP. Public hearings on its implementation are expected to continue into 1999.

VAMP's experimental period generally coincides with the Bay-Delta Plan's spring export



**Figure 4-11.** Combined Delta exports as percent of inflow diverted and Bay/Delta Plan objectives, 1998

**Table 4-10.** Bay-Delta Plan Export Limits Based on Percentage of Delta Inflow Diverted, 1998.

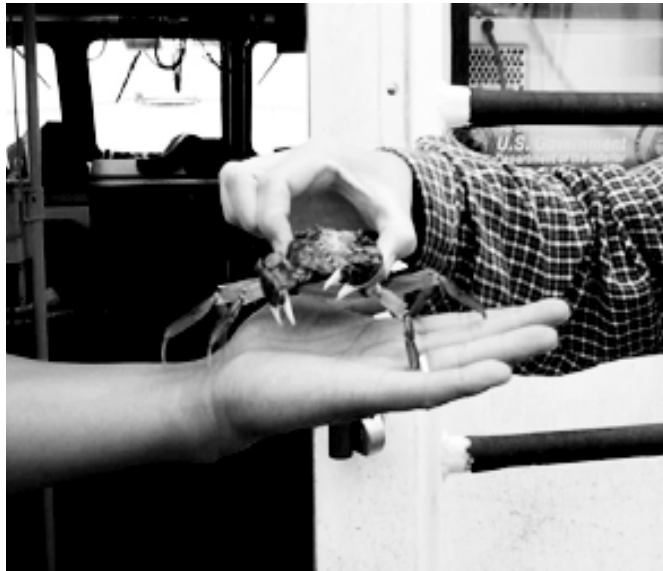
Month	Maximum % Inflow allowed as combined export	Mean % inflow diverted	
		3-day running mean <sup>a</sup>	14-day running mean <sup>a</sup>
Jan	65	23.0	26.1
Feb		1.5	1.7
Mar		1.9	1.8
Apr <sup>b</sup>	35	1.6	1.5
May <sup>b</sup>		4.6	4.5
Jun		6.2	5.9
Jul		17.2	15.3
Aug		25.9	25.4
Sep	65	27.6	27.0
Oct		40.1	37.4
Nov		21.6	22.0
Dec		4.5	4.3

<sup>a</sup>Percent of Delta inflow diverted is calculated using the export rate as a 3-day running means and the Delta inflow as a 14-day running mean, except when the SWP or CVP are making storage withdrawals for export. In this case, both the export rate and Delta inflow are 3-day running means.

<sup>b</sup>The Bay-Delta Plan limits combined April 15-May 15 export rate to 1,500 cfs or 100% of San Joaquin River Flow at Vernalis, whichever is greater (see Table 4-6).

Note: Combined export is defined as Clifton Court Forebay inflow (minus BBID diversions from Clifton Court) plus Tracy Pumping Plant exports.

restriction period of April 15 to May 15. Due to high San Joaquin River flows in the spring of 1998, an alternate fisheries study associated with VAMP was implemented that limited Delta exports to 3,000 cfs when Vernalis flows are above 15,000 cfs. Exports at Banks occurred on only 7 days of the spring export restriction and Tracy Pumping Plant exported the vast majority of water during this period, averaging about 1,900 cfs.



*A mitten crab aboard the San Carlos, the Department's floating water quality laboratory*

**Impact of Chinese Mitten Crabs.** Currently, the most conspicuous impact of mitten crabs in California is on the fish salvage operations of the SWP and CVP at their respective export facilities in the south Delta. In 1998, mitten crabs were entrained year-round and almost 1 million were entrained at the federal facility alone. Fish salvage operations at SWP's Skinner Fish Facility and the Tracy Fish Collection Facility were severely hindered by the large numbers of mitten crabs in the holding tanks and fish transport trucks; however,

the mitten crab inundation did not have a significant impact on exports during 1998.

### **Real-time Monitoring Program**

The 1994 Principles of Agreement endorsed the use of RTM to enhance operational flexibility through the adjustment of export limits while insuring biological protection consistent with the federal and State ESA. The 1998 Real-time Monitoring Program provided water project operators with field information and monitoring data within 36 hours, timely enough to protect targeted fish species from entrainment at the Delta export facilities while providing for water supply reliability. It began in November 1997 with a limited program and was expanded to the more intensive field portion beginning on April 1 and ending June 30, 1998. Monitoring specifically targeted winter-run salmon, Delta smelt, and Sacramento splittail, the CALFED Operations Group evaluated the field results to determine if there was any need for operational change. USFWS have been proposing the listing of the Sacramento splittail since 1994; the decision to list the species as threatened was postponed again in 1998.

RTM efforts during spring and early summer of 1998 sampled seven Delta sites 5 days per week. The results indicated that high spring and summer Delta outflows helped move young-of-the-year Delta smelt downstream into Suisun Bay and away from the SWP and CVP export facilities.

### **North Bay Aqueduct Operations**

The NBA system, completed in May 1988, begins in the north Delta at the Barker Slough facilities near Rio Vista. Sacramento River and local watershed water passes through Cache, Lindsey, and Barker Sloughs to reach the Barker Slough Pumping Plant. From the Barker Slough Pumping Plant, water is conveyed by pipeline for 24 miles northwest to the Cordelia Pumping Plant. Deliveries are made to Solano County water users via turnouts along the pipeline and to Napa County users from the Cordelia Pump-

ing Plant. NBA extends approximately 6 miles beyond the Cordelia Pumping Plant to the Napa Terminal Tank. The Aqueduct will ultimately supply 25 taf annually to Napa County and 42 taf annually to Solano County. In 1998, NBA conveyed 35,125 af of SWP long-term water contractor supply—85 percent of the total NBA deliveries (29,766 af) went to SCWA and Napa received 5,359 af (about 15 percent). No non-SWP deliveries were made in 1998.

The Barker Slough Pumping Plant has a maximum pumping capacity of 160 cfs and is screened to exclude juvenile salmon from entrainment; however, the screens are not able to exclude the smaller Delta smelt. The amended Delta smelt opinion requires a reduction of diversions from Barker Slough to a 5-day running average of 65 cfs when monitoring efforts at two sites upstream of the plant detect Delta smelt under 20 millimeters. The catch at three stations in Barker Slough were calculated into a weighted average, with the weight of each station dependent upon the proximity to the Barker Slough pump intake. The opinion also set an estimated numerical loss limit at the pumping plant during Delta smelt spawning season.

From March 3 to July 17, 1998, the Delta smelt catch at the three Barker Slough stations did not rise to the level described in the amended biological opinion to establish Delta smelt presence and consequently no export reductions were required.

### **Delta Water Management**

#### **Interim South Delta Program**

ISDP is designed to improve water levels and circulation in the south Delta channels to improve the amount and quality of water transfers through the south Delta. The program is composed of five major components:

- (1) a new intake structure at Clifton Court Forebay,
- (2) channel dredging along a reach of Old River,

- (3) seasonal barriers in Old River,
- (4) three new flow control structures, and
- (5) increased diversions into Clifton Court Forebay.

In combination with other actions, ISDP is being considered for implementation during the next 5 to 7 years as part of the CALFED preferred alternative for the Delta.

### Seasonal Barriers.

The seasonal barriers are constructed under the program's South Delta Temporary Barriers Project. The barriers are designed to improve local water levels and circulation patterns, protect fishery resources, and improve water quality. The temporary barriers have been placed across Middle River, Old River at Tracy, Grant Line Canal, and Old River at Head (Figure 4-12). In

1996, COE extended the testing program of the temporary barriers for another 5 years. The 5-year barriers testing period extension will include an evaluation of means to improve Chinook salmon survival during spring and fall migrations.

The Old River at Head barrier, a temporary barrier installed in the spring, prevents salmon from straying from their migration route into interior Delta sloughs and channels. During the fall, the Department installs a similar temporary rock barrier at the same location at DFG's

request. The fall barrier helps the salmon migrating upstream remain in their San Joaquin River migration path by minimizing straying into inner south Delta channels. The Old River at Head fall barrier also improves flows in the San Joaquin River which help to alleviate low DO conditions in the Stockton Deep Water Ship Channel.



*The Grant Line Canal temporary barrier is installed during the summer of most years to protect migrating San Joaquin River salmon and to insure that adequate quantity and quality of agricultural water is available.*

The Middle River barrier is a temporary rock barrier installed near Victoria Canal, located about one-half mile south of the confluence of Middle River and Trapper Slough. This barrier is tidally controlled and improves water circulation and water levels during the agricultural irrigation season. The Old River barrier at Tracy has been installed annually in spring since 1991. It is located on Old River, east of the Delta-Mendota Canal intake at Tracy Pumping

Plant, and provides benefits similar to those of the Middle River barrier. The Department began installing a new barrier located on Grant Line Canal east of Tracy Boulevard Bridge in 1996. The Grant Line barrier is the last barrier proposed for testing under SDTBP. It is designed to enhance water levels, water quality and circulation, fish migration in the south Delta, and improve agricultural operations. High flows on the San Joaquin River prevented the installation of all the temporary barriers during 1998.

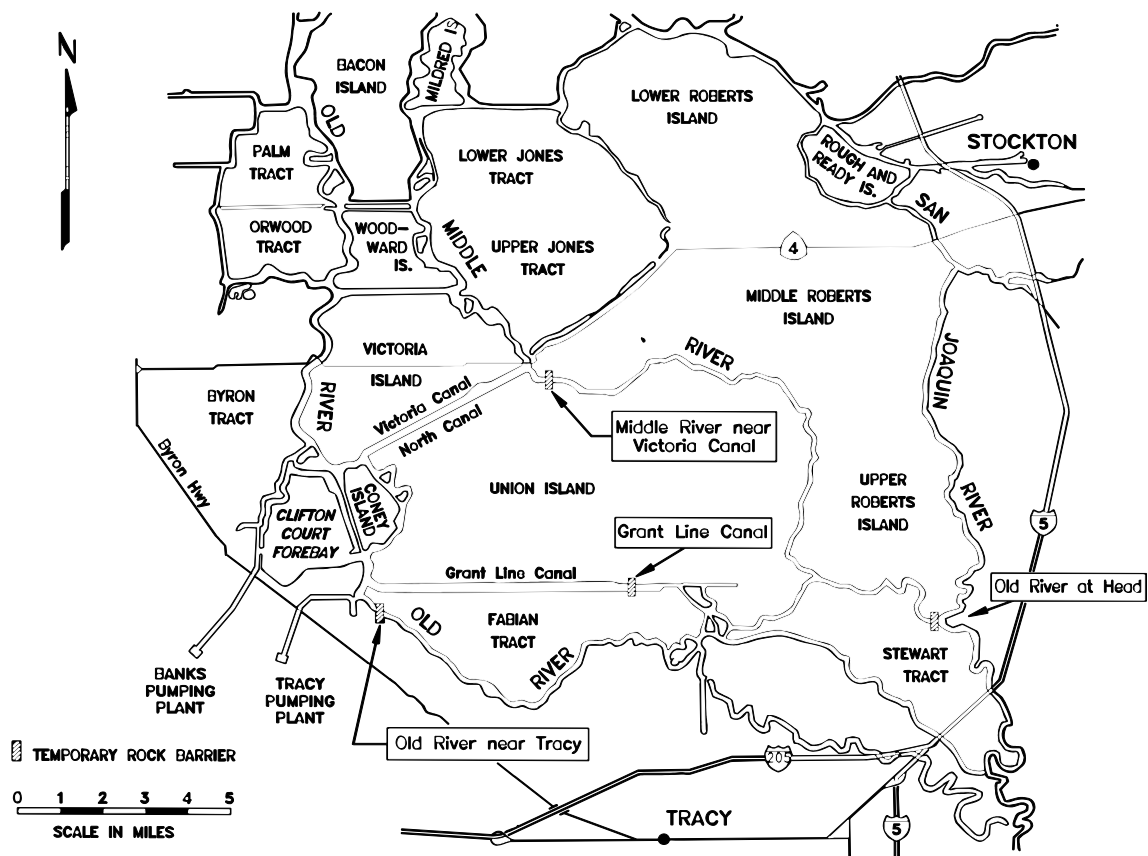


Figure 4-12. South Delta barriers

# 5. Delta Water Quality Standards

The water quality of the Sacramento-San Joaquin Delta is influenced by the rate and quality of tributary inflows and agricultural drainage (including drainage from the Delta islands), as well as seawater intrusion into the Delta's western channels. The SWP and CVP are required, under their SWRCB water right permits, to meet the water quality objectives in the 1995 Bay-Delta Water Quality Control Plan, which was designed to protect the beneficial uses of Delta water. The Principles of Agreement, also referred to as the Bay/Delta Accord, were designed to balance proposed SWRCB water quality standards and ESA operational criteria imposed by National Marine Fisheries Service and the U.S. Fish and Wildlife Service, with the need to provide water supply reliability.

SWRCB's 1995 Bay-Delta Plan objectives will become standards with the completion of the CEQA process that examines the potential impacts of the plan's implementation. In 1995, D-1485 and D-1422 permits were amended to conform to Bay-Delta Accord principles and the 1995 Bay-Delta Plan through SWRCB's WR 95-6. In some cases, the Bay-Delta Plan water quality objectives may differ from those in the retained and amended D-1485 standards. Whenever this occurs, the more stringent of the two applies.

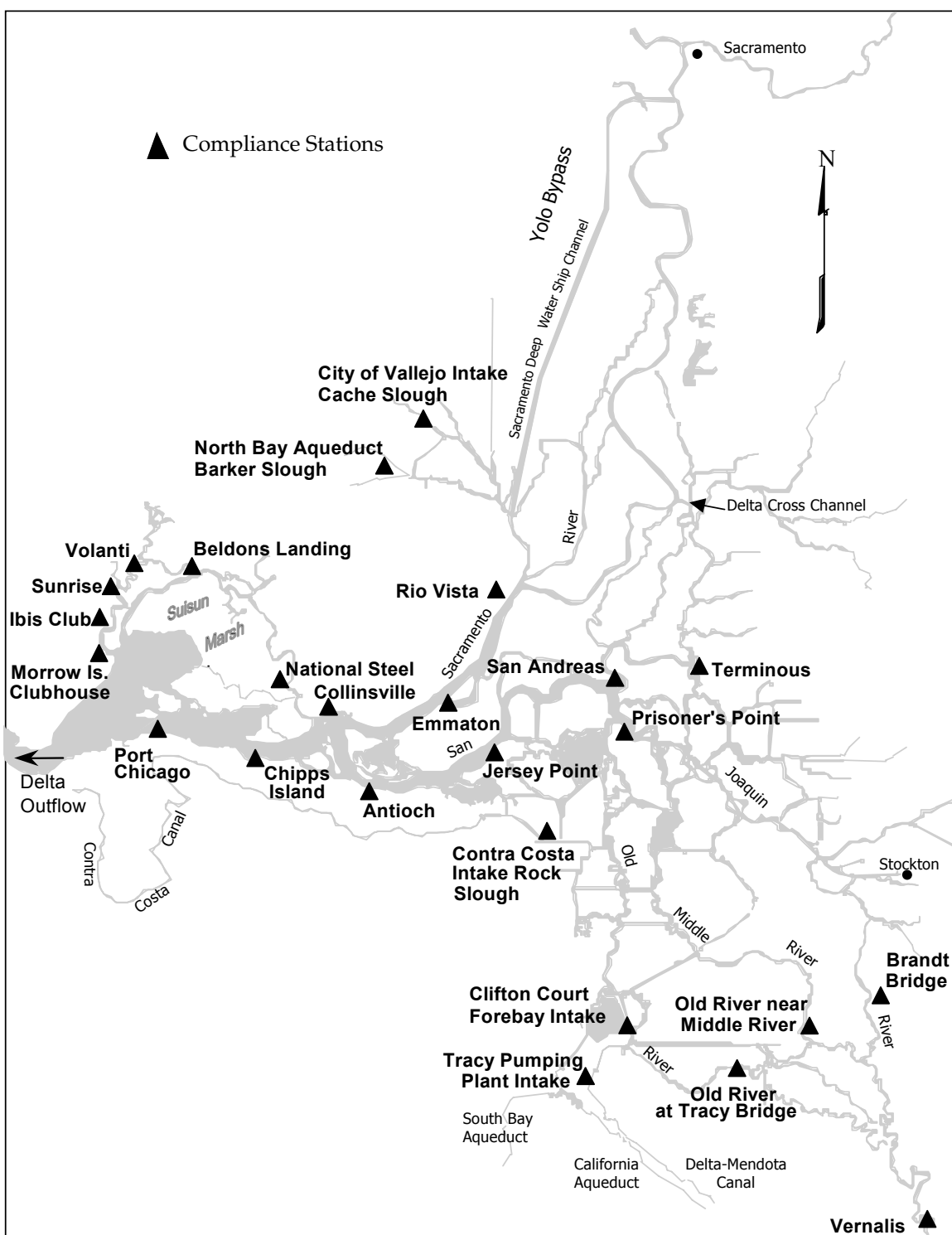
Water quality standards and objectives are categorized by the beneficial uses they are intended to protect under broad categories that include municipal and industrial, agricultural, and fish and wildlife. The water quality compliance stations, including Suisun Marsh sites, are shown in Figure 5-1. The Department attempts to meet

Bay-Delta Plan objectives and amended D-1485 water quality and flow standards through the following measures: (1) releases from upstream reservoirs, (2) operation of the Delta Cross Channel gates, (3) Delta exports operations, and (4) the construction of temporary rock barriers.

The 1995 Bay-Delta Plan incorporates the D-1422 San Joaquin River salinity standard at Vernalis and a multi-location San Joaquin River DO objective. The plan also introduced a narrative objective for salmon protection and for the protection of brackish tidal marshes of Suisun Bay. Operational objectives and standards are summarized in Table 5-1.

## **Municipal and Industrial Standards**

Municipal and industrial water quality standards based on mean daily chloride values are set at Delta export locations which include Clifton Court Forebay, Tracy Pumping Plant, Contra Costa Canal at Pumping Plant #1, Barker Slough, and Cache Slough. The Clifton Court Forebay and Tracy Pumping Plant are the start of the SWP's California Aqueduct; the Delta-Mendota Canal is the start of CVP's aqueduct. The Contra Costa Canal Intake at Rock Slough is at the start of a supply canal that conveys water to eastern Contra Costa County. Cache Slough is an intake for the City of Vallejo. The Cache Slough standard was not in effect in 1998 as no water has been withdrawn from the site in several years. A mean daily chloride standard of not more than 250 mg/L was in effect for the entire year at all the other export locations and was met at all stations during 1998 (Figure 5-2).

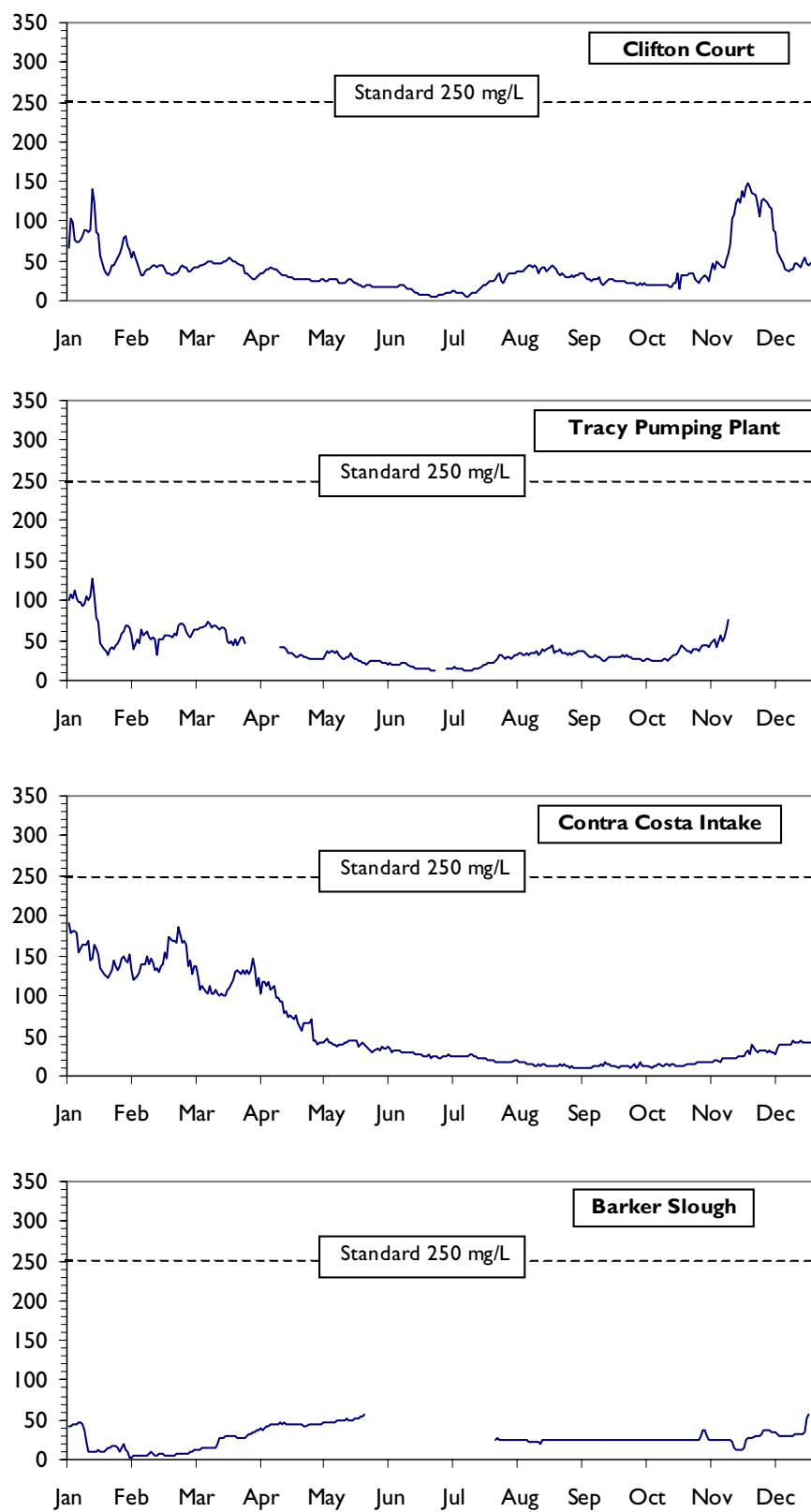


**Figure 5-1.** The location of the SWRCB 1995 Bay-Delta water quality compliance stations in the Sacramento-San Joaquin Delta (indicated by triangles).

**Table 5-1.** Bay-Delta Plan and Amended D-1485 Wet Year Water Quality Standards for the Sacramento-San Joaquin Delta during 1998

Compliance Location	Beneficial Use	Standard
<b>Municipal and Industrial</b>		
Contra Costa Canal Intake, Clifton Court Forebay, Tracy Pumping Plant, Contra Costa Canal Intake, Barker Slough Pumping Plant, and Cache Slough Vallejo Intake	md CL <250	All months
Contra Costa Canal Intake or Antioch Water Intake	daily CL <150	240 days in the year
<b>Agriculture</b>		
<i>Western and Interior Delta</i> Emmaton, Jersey Point, Terminous, and San Andreas Landing	14 dm EC < 0.45	April 1-August 15
<i>Southern Delta</i> San Joaquin River at Vernalis	30 dm EC <0.7 30 dm EC <1.0	April-August September-March
<i>Export Area</i> Clifton Court Forebay and Tracy Pumping Plant	mm EC <1.0	all months
<b>Fish and Wildlife</b>		
<i>Dissolved Oxygen</i> San Joaquin River between Turner Cut and Stockton	DO >6.0	September-November
<i>San Joaquin River Salinity</i> Jersey Point to Prisoners Point	14 dm EC <0.44	April-May
<i>Habitat Protection Salinity Starting Condition</i> February starting salinity: - If January 8-River Index > 900 TAF, then the daily or 14-day running average EC at Collinsville ≤2.64 mS/cm for at least one day between February 1-14. - If January 8-River Index is between 650 TAF and 900 TAF, then the CALFED's Op Group will determine if this requirement must be met. See Table 5.3 for Determination of Compliance of 2.64 mS/cm at Chipps Island or Port Chicago. <i>Suisun Marsh (see Table 5.4)</i>		

Note: DO: dissolved oxygen (mg/L); CL: chlorides (mg/L); EC: electrical conductivity (mS/cm); md: mean daily; 30 dm: 30-day running mean; 14 dm: 14-day running mean; mm: mean monthly; 28 dm: 28-day running mean.



**Figure 5-2.** Municipal and industrial water quality standards, 1998

The 1995 Bay-Delta Plan retained the D-1485 water quality standard requiring chlorides not to exceed 150 mg/L for intervals of at least 2 weeks, at the better of two stations, either the Contra Costa Canal Pumping Plant #1 or the Antioch Water Works intake. The percentage of days in the calendar year required by the standard is a function of water year type. It varies between 42 and 66 percent of the year, becoming less stringent under drier conditions. The wet year 240-day (66 percent of the year) criterion at the Contra Costa Canal Pumping Plant #1 was met on October 10, 1998.

### Agricultural Standards

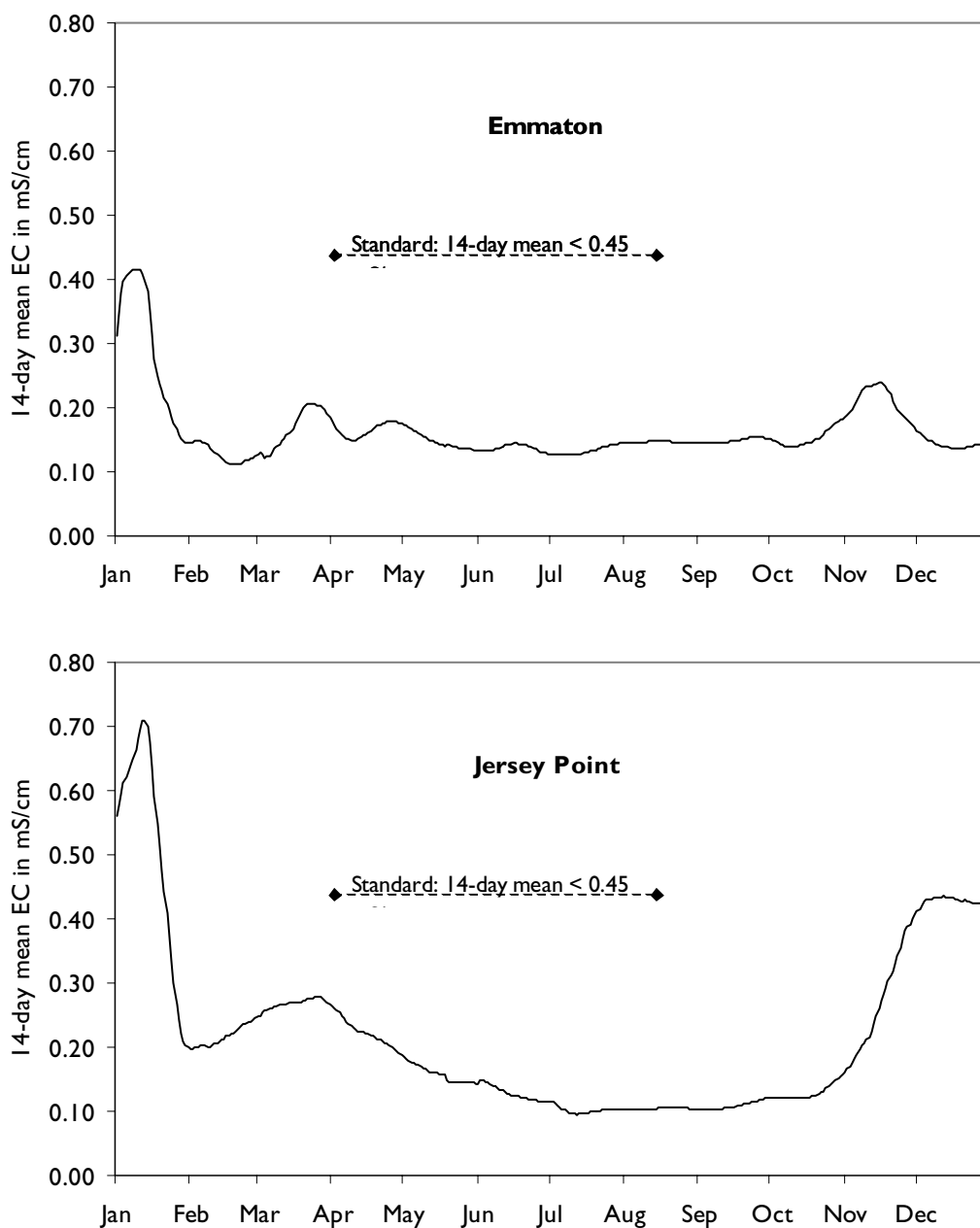
D-1485 sets agricultural EC standards to protect Delta agriculture during the irrigation season (April 1 to August 15). Compliance locations in the western Delta include Emmaton and Jersey Point; San Andreas Landing and Terminous are the compliance locations in the interior Delta. The Bay-Delta Plan set additional year-round compliance locations in the southern Delta at Vernalis and Brandt Bridge and, during September-October, near the export areas at Clifton Court Forebay and Tracy Pumping Plant. When hydrologic conditions are drier than average,

the standards are relaxed during the latter part of the irrigation season to reflect the water quality that would have occurred in the absence of the SWP and CVP. Under critical year conditions, relaxation occurs for the entire growing season to reflect salinity intrusions expected with lower basin runoff into the Delta. The wet year agricultural water quality standard is set as a maximum 14-day running average EC of 0.45 mS/cm at Emmaton, Jersey Point, Terminous, and San Andreas Landing. The Vernalis agricultural standard, based on a 30-day running average, is set at 0.70 mS/cm from April-August and rises to 1.0 mS/cm September-March. The year-round export area standard (maximum monthly average) is also 1.0 mS/cm (Figures 5-3, 5-4, and 5-5).

The responsibility for meeting standards and objectives is generally apportioned under COA to be met by the Department and the Bureau, with the exception of the south Delta San Joaquin River agricultural objectives at Vernalis and Brandt Bridge. SWRCB allocated compliance responsibility expressly to the Bureau since the Department does not regulate any reservoirs upstream of the San Joaquin River. During 1998, the Department met all standards for which it



*There are about 1,800 agricultural water diversions in the Delta. Seventy percent of the Delta's 738,000 acres are devoted to agricultural use.*

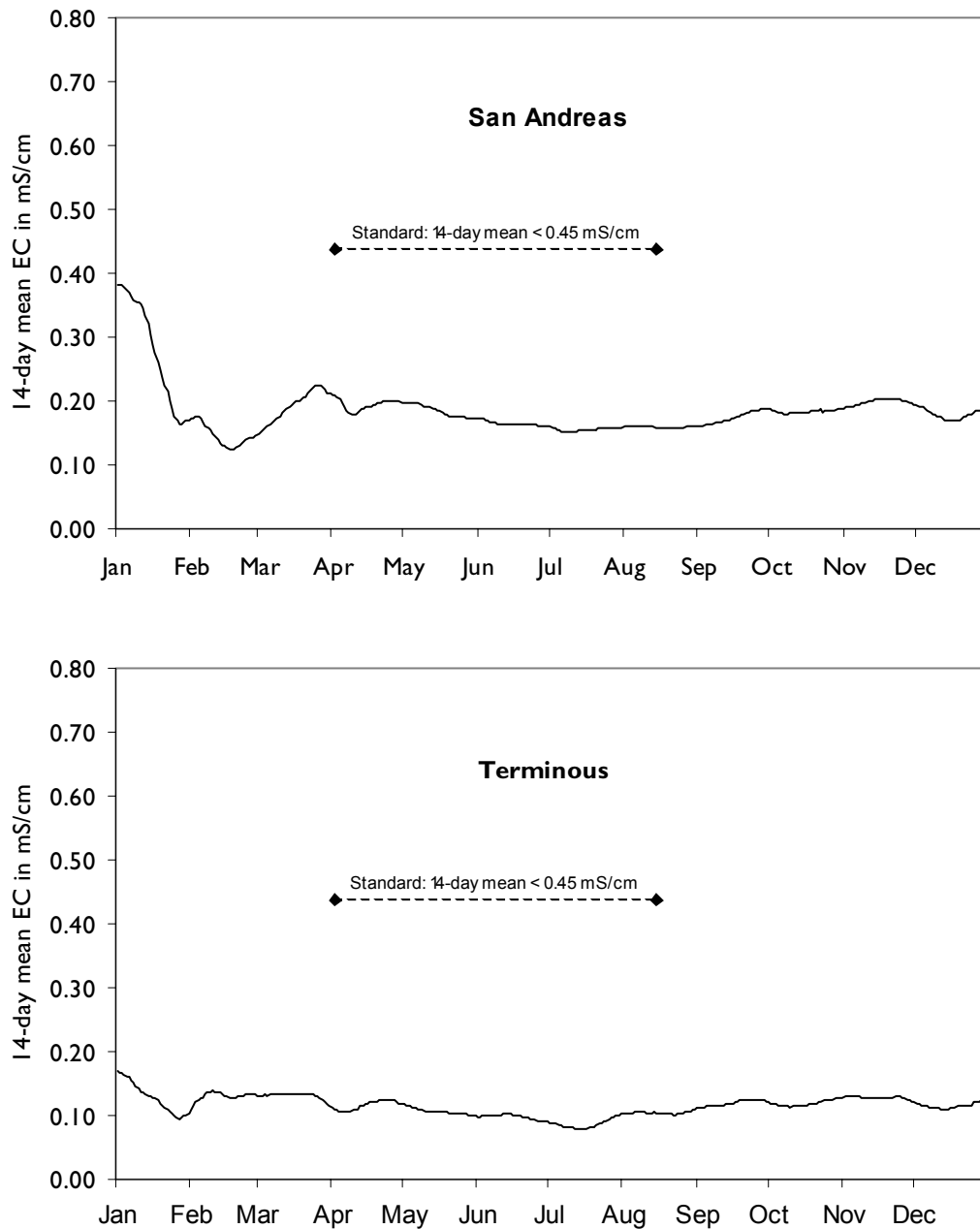


**Figure 5-3.** Agricultural standards in the western Delta, 1998

has responsibility under COA and SWRCB. These included the Emmaton, Jersey Point, Terminous, and San Andreas Landing agricultural standards. The Department also has an obligation to maintain water quality for agricultural uses under the 1981 North Delta Water Agency contract, as amended.

### Fish and Wildlife Standards

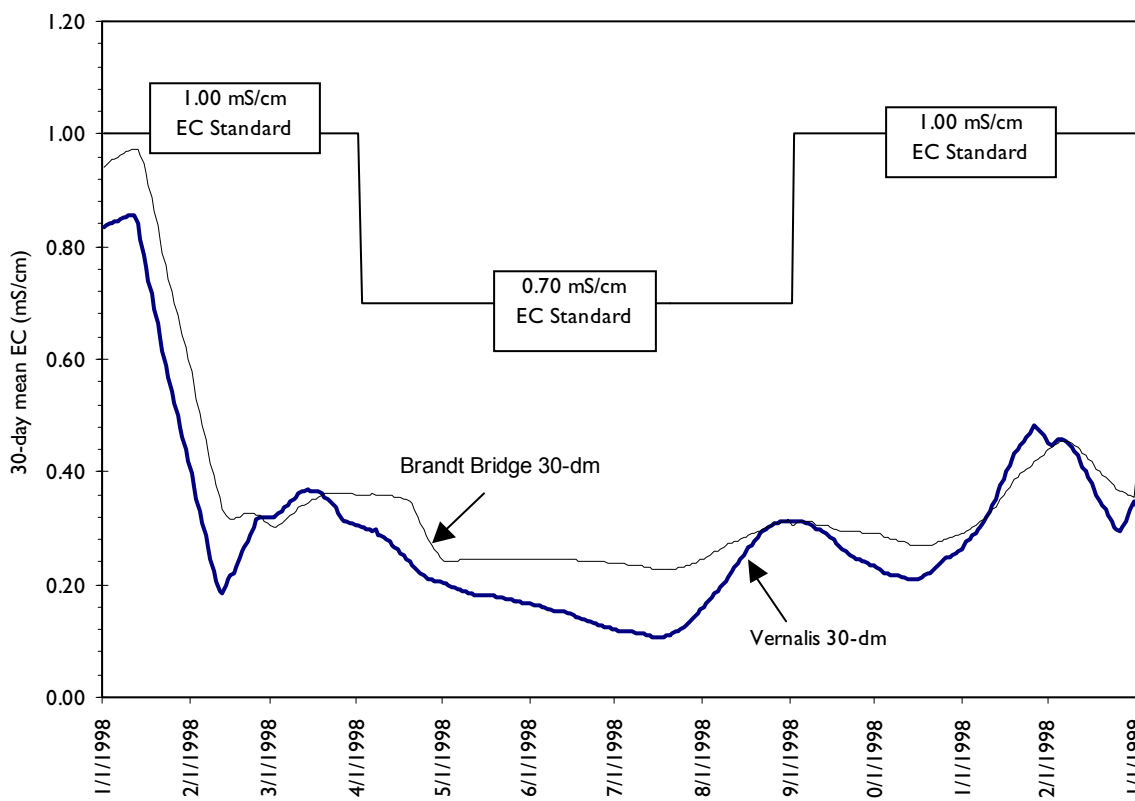
The Bay-Delta Plan and amended D-1485 introduced several new water quality objectives to protect Delta fish and wildlife. These included a water quality objective for EC on the San Joaquin River measured between Jersey Point



**Figure 5-4.** Agricultural standards in the interior Delta, 1998

and Prisoners Point and several new standards in the Suisun Marsh. Suisun Marsh standards are included below in a more extensive discussion under Suisun Marsh Protection Plan and Preservation Agreement. Other new objectives combining both EC and flow were set to protect

the estuarine habitat in the Suisun Bay area. A San Joaquin River DO objective was also introduced, having been carried over from D-1422. All these measures were established in part to encourage the spawning and survival of striped bass and to protect migrating salmon.



**Figure 5-5.** San Joaquin River EC standards, 1998 (Note: SWRCB assigned responsibility for meeting standards to the Bureau alone.)

## San Joaquin River Salinity Standard

The Jersey Point and Prisoner's Point objective is set as a maximum 14-day running mean of 0.44 mS/cm during April and May to protect striped bass spawning habitat. Compliance with the Prisoner's Point EC standard is actually measured at San Andreas Landing, which provides a conservative estimate due to its location west of Prisoner's Point. Jersey Point values averaged 0.19 mS/cm and never rose over 0.26 mS/cm. EC at San Andreas Landing averaged 0.19 mS/cm for the period and never rose above 0.20 mS/cm.

## Dissolved Oxygen Standard

The 1995 Bay-Delta Plan includes a DO standard to protect fall-run salmon migration in the lower San Joaquin River similar to, but more

stringent than, the DO standard in D-1422. Minimum DO levels are set at 6.0 mg/L during September through November. During late summer and early fall each year, DO concentrations in the Stockton Ship Channel are closely monitored because they can deteriorate to critically low levels (<5.0 mg/L). DO is measured at 14 sites, at both the water surface and at the channel bottom, between Prisoner's Point and the Stockton Deep Water Channel turning basin.

Low oxygen conditions may result from many factors including low stream inflows; intermittent reverse-flow conditions in the San Joaquin River past Stockton; warm water temperatures; reduced tidal mixing; and high biochemical oxygen demand levels as the result of regulated discharges in the Stockton area and recreational activity adjacent to the basin. The Department's Operation Control Office monitors the DO

conditions in the Stockton Ship Channel as the basis for some operational decisions. The fall installation of the head of Old River barrier is a commonly used remedy for low DO conditions in the lower San Joaquin River. The barrier increases net flows down the San Joaquin River past Stockton and these increased flows help to improve DO levels, particularly in the eastern channel. The fall Old River at Head barrier was not installed in 1998 because of abundant flow conditions on the San Joaquin River during the late summer and early fall. Average daily flows at Vernalis ranged from about 4,750 to 6,700 cfs from August through October, while flows past Stockton ranged from 1,000 to 2,000 cfs during the same timeframe. As a result, August 7 through October 20 monitoring at the 14 sites from Prisoner's Point to the Stockton Turning Basin revealed that all DO readings, at the surface and bottom, exceeded 5.0 mg/L.

Despite the high San Joaquin River inflows into the eastern Stockton Ship Channel, a DO depression (an area where DO levels were 6.0 mg/L or less) occurred in the central channel, from Columbia Cut to Fourteen Mile Slough, in August and early September. This area was west of Rough and Ready Island in the

eastern channel, where levels less than 5.0 mg/L have generally occurred.

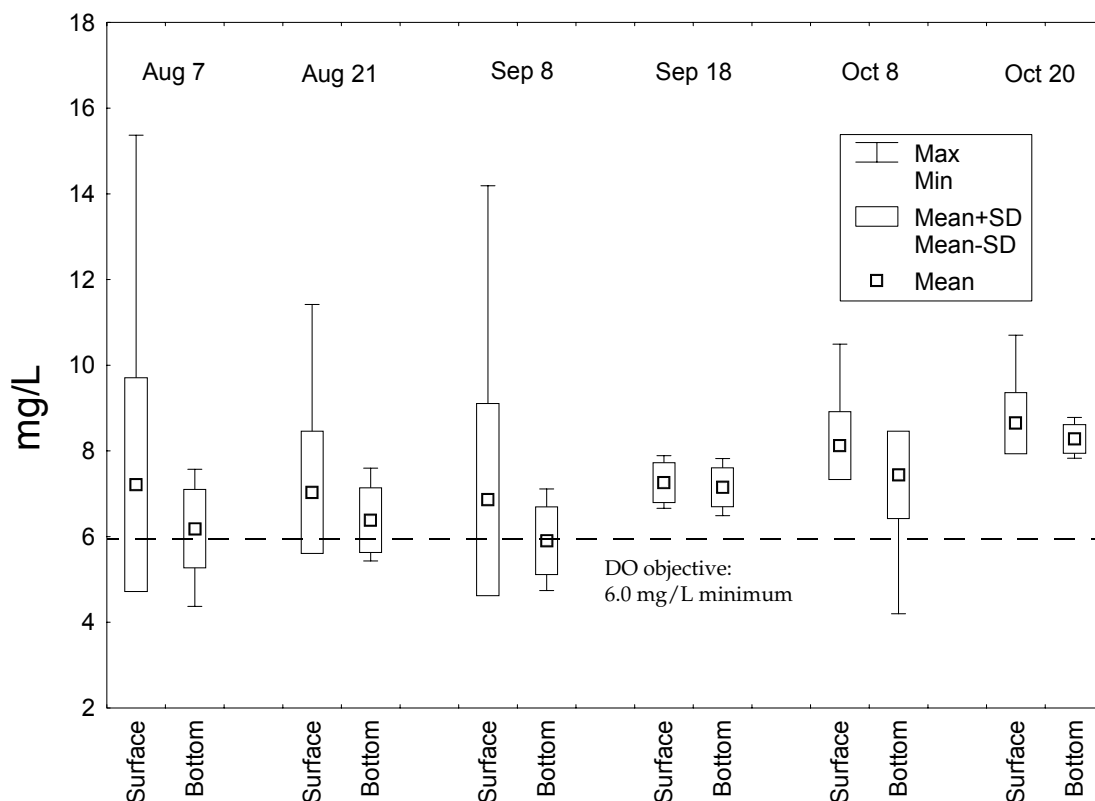
Relatively warm water temperatures measured within the channel in August and early September contributed to the DO depression in the channel in late summer 1998. However, at the range of water temperature values experienced in late summer 1998, DO levels have been lower (less than 5.0 mg/L) in the eastern channel in previous years.

High San Joaquin River inflows into the eastern channel immediately east of Rough and Ready Island were enough to push the area of depressed DO levels westward from the historical sag area in the eastern channel to the central portion of the channel. Greater tidal fluctuations and water column mixing within the central portion of the channel may have contributed to the improved DO levels.

By September 18, 1998, the late summer DO depression in the channel was eliminated. By October 20, 1998, DO levels in the channel rose to more than 8.0 mg/L as a result of cooler water temperatures and sustained high San Joaquin River inflows into the channel (Figure 5-6).



*Commercial traffic in the Stockton Ship Channel*



**Figure 5-6.** Dissolved oxygen concentration levels in the Stockton Ship Channel, 1998

### Estuarine Habitat Protection Objective (X2)

The Bay-Delta Plan includes an estuarine habitat protection objective that incorporates a modified X2 criteria (geographic isohaline), which was first established in the 1994 Delta Smelt Biological Opinion. Outflow is used to maintain the position of a 2 ppt isohaline (2 parts per thousand of salt in the water), measured as 2.64 mS/cm on the water's surface at either Chipps Island or Port Chicago from February through June. The required location of the isohaline is associated with fish and biota abundance.

The number of days per month when the daily averaged EC maximum (2.64 mS/cm) is in effect at Chipps Island or, under specific conditions, at Port Chicago, are conditioned by PMI and are noted in the Bay-Delta Plan's Table A

(Table 5- 2). The Port Chicago standard is usually in effect during months when the Port Chicago 14-day EC average immediately prior to the first day of the month is  $\leq 2.64$  mS/cm. If salinity or flow objectives are met for a greater number of days than the requirement for any month, the excess days are applied to meeting the requirements for the following month.

The daily averaged EC objective may be alternately met with a 14-day running average of EC for both locations, or a flow alternative set as a 3-day running average of NDOI for the required number of days. The NDOI objective is set at 11,400 cfs or 29,200 cfs when the X2 is located at Chipps Island or Port Chicago, respectively. During 1998, PMI for February through June was 5.19 maf, 7.44 maf, 5.11 maf, 4.53 maf, and 5.53 maf, respectively. Using Table A, the number of days of compliance maintaining a maximum EC of 2.64 mS/cm at Port Chicago was

**Table 5-2. Bay-Delta Standards Table A: Habitat Protection Outflow**

Chipps Island						Port Chicago					
PMI (TAF)	Feb	Mar	Apr	May	Jun	PMI (TAF)	Feb	Mar	Apr	May	Jun
500	0	0	0	0	0	0	0	0	0	0	0
750	0	0	0	0	0	250	1	0	0	0	0
1,000	28 <sup>a</sup>	12	2	0	0	500	4	1	0	0	0
1,250	28	31	6	0	0	750	8	2	0	0	0
1,500	28	31	13	0	0	1,000	12	4	0	0	0
1,750	28	31	20	0	0	1,250	15	6	1	0	0
2,000	28	31	25	1	0	1,500	18	9	1	0	0
2,250	28	31	27	3	0	1,750	20	12	2	0	0
2,500	28	31	29	11	1	2,000	21	15	4	0	0
2,750	28	31	29	20	2	2,250	22	17	5	1	0
3,000	28	31	30	27	4	2,500	23	19	8	1	0
3,250	28	31	30	29	8	2,750	24	21	10	2	0
3,500	28	31	30	30	13	3,000	25	23	12	4	0
3,750	28	31	30	31	18	3,250	25	24	14	6	0
4,000	28	31	30	31	23	3,500	25	25	16	9	0
4,250	28	31	30	31	25	3,750	26	26	18	12	0
4,500	28	31	30	31	27	4,000	26	27	20	15	0
4,750	28	31	30	31	28	4,250	26	27	21	18	1
5,000	28	31	30	31	29	4,500	26	28	23	21	2
5,250	28	31	30	31	29	4,750	27	28	24	23	3
5,500	28	31	30	31	30	5,000	27	28	25	25	4
						5,250	27	29	25	26	6
						5,500	27	29	26	28	9
						5,750	27	29	27	28	13
						6,000	27	29	27	29	16
						6,250	27	30	27	29	19
						6,500	27	30	28	30	22
						6,750	27	30	28	30	24
						7,000	27	30	28	30	26
						7,250	27	30	28	30	27
						7,500	27	30	29	30	28
						7,750	27	30	29	31	28
						8,000	27	30	29	31	29
						8,250	28	30	29	31	29
						8,500	28	30	29	31	29
						8,750	28	30	29	31	30
						9,000	28	30	29	31	30
						9,250	28	30	29	31	30
						9,500	28	31	29	31	30
						9,750	28	31	29	31	30
						10,000	28	31	30	31	30
						10,000	28	31	30	31	30

<sup>a</sup>When 800 taf < PMI.

Note: Number of days when maximum daily average EC 2.64 mS/cm must be maintained. (This can also be met with maximum 14-day running average EC of 2.64 mS/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mS/cm or less. PMI is previous month's SRI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of days or values of the PMI between those specified below shall be determined by linear interpolation.

27 days for February and 30 for March; April, May, and June required 25, 22, and 11 days, respectively (Table 5-3, Figure 5-7).

The X2 Habitat Protection objective at Port Chicago during February through June 1998 was easily met with all three compliance criteria (mean daily EC, 14 day mean of EC, and 3-day mean of NDOI > 29,200 cfs) accumulating the required number of days for compliance.

### Suisun Marsh Protection Plan and Preservation Agreement

The Suisun Marsh, located in southern Solano County, provides one of the largest estuarine waterfowl habitats in the continental U.S. and represents more than 10 percent of California's remaining natural wetland habitat. The marsh also provides resting and feeding grounds for thousands of waterfowl migrating on the Pacific Flyway.

Suisun Marsh water quality has been protected since 1971, first through the SWRCB's Decision 1379 and later, in 1978, by D-1485. In 1987, the Department signed the Suisun Marsh Preservation Agreement in conjunction with the Bureau, DFG, and the Suisun Resources Conservation District, which represents private landowners. In 1995, SWRCB WR 95-6 eliminated the Chipps Island running 28-day salinity average standard and the eastern marsh standard at Mallard. WR 95-6 added a new narrative objective for the brackish tidal marshes of Suisun Bay to protect remnant tidal marshes and changed the compliance date for two western Suisun Marsh stations to October 1997, although SWRCB twice granted extensions, thus pushing the compliance requirement to the end of 1998. The extension allowed time for SMPA parties to begin implementing SMPA Amendment Three actions that will provide enhanced protection to the western marsh.

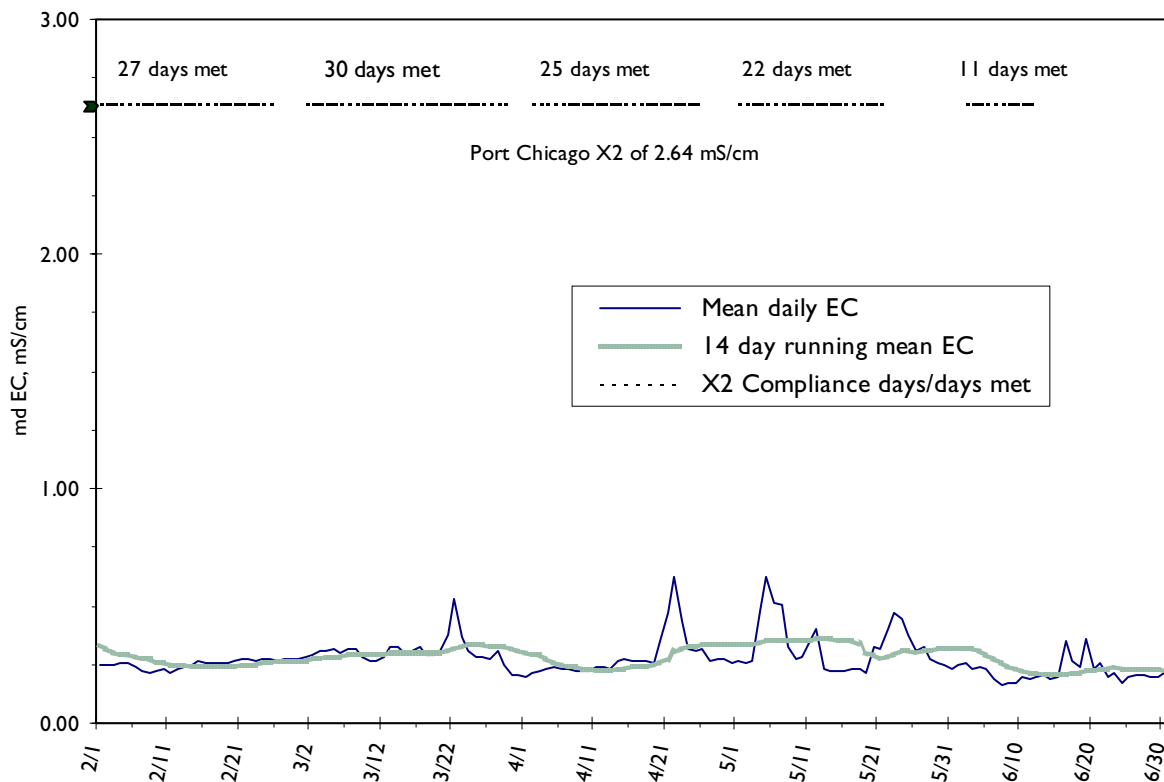
**Table 5-3.** Determination of Habitat Protection Compliance during 1998

Month	PMI <sup>a</sup>	Location	Compliance		Carryover Days <sup>b</sup>	Criteria Used to Meet Objective <sup>c</sup>
			Required Days	Days Met		
Feb	5.19	Port Chicago	27	28 28 28	1 1 1	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
Mar	7.44	Port Chicago	30	31 30 31	1 0 1	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
Apr	5.11	Port Chicago	25	31 30 30	6 5 5	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
May	4.53	Port Chicago	22	31 29 31	9 7 9	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
Jun	5.53	Port Chicago	11	30 30 30	19 19 19	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC

<sup>a</sup>PMI - Previous month's Eight River Index in maf.

<sup>b</sup>Carryover days may be used to meet the next month's requirement, if at the same compliance location.

<sup>c</sup>Compliance may be met using either daily EC, 14-dm EC < 2.64 mS/cm or specific 3-dm of NDOI.



**Figure 5-7.** Days of X2 (EC < 2.64 mS/cm) compliance at Port Chicago, 1998

The Suisun Marsh Salinity Control gates first began operation in 1989 and operate as needed during a control season from October 1 to May 31. The gates, located 2 miles downstream from Collinsville in Montezuma Slough, respond to daily tidal fluctuations, open to admit fresher flow from the Sacramento River, and close to block tidal salt-water intrusion from Suisun Bay. They are considered to be in full operation when all three gates are tidally operated, the flashboards have closed off the channel, and the boat lock is operational.

The USFWS Delta Smelt Biological Opinion, revised March 1995, requires that SMSCG be operational to meet the Bay-Delta Plan objectives for salinity. During the tenth control season (October 1, 1997, through May 31, 1998), the control gates were operated from October 14 through December 3, 1997. Abundant precipitation lowered salinity throughout the marsh, making it unnecessary to operate the gates dur-

ing the balance of the tenth control season. On February 3, 1998, the flashboards were removed as a result of flooding concerns in the marsh and they were not reinstalled until the start of the eleventh control season in late September 1998.

Although the flashboards were in position, the control gates were not needed to meet salinity standards during the first half of the eleventh control season (October, November, and December 1998); however, the gates were operated intermittently during this period as part of a joint study by the Department, the Bureau, DFG, SRCD, and NMFS to evaluate the use of modified flashboards to encourage the passage of adult salmon.

All Suisun Marsh salinity standards in effect at Beldons Landing and National Steel on Montezuma Slough, Chadbourne Slough at Sunrise Club, Collinsville, and Volanti were met during 1998 (Table 5-4).

**Table 5-4.** Amended D-1485 Suisun Marsh Salinity Standards in Effect during 1998

Month	Standard MHTEC	Actual MHTEC <sup>a</sup>				
		C-2 Collinsville	S-64 National Steel	S-49 Beldons Landing	S-21 Sunrise Club	S-42 Volanti
Tenth Control Season						
January	12.5	1.5	3.0	5.5	5.7	5.8
February	8.0	0.3	0.2	0.5	a	1.1
March	8.0	0.2	0.3	0.7	1.3	1.3
April	11.0	0.2	0.4	0.6	1.2	1.2
May	11.0	0.2	0.4	0.7	1.2	1.2
Eleventh Control Season						
October	19.0	0.5	0.7	2.1	b	2.7
November	15.5	1.0	1.5	3.6	b	4.5
December	15.5	0.1	0.4	2.0	1.71 <sup>c</sup>	2.4

MHTEC - Monthly average of both daily high-tide ECs in mS/cm.

<sup>a</sup>Data not available due to power failure caused by flooding.

<sup>b</sup>Data failed quality assurance/quality control analysis.

<sup>c</sup>Value may be biased due to limited data caused by equipment.

Note: Additional stations S-35 and S-97 not in effect because of SWRCB variance issued as part of WSCT.

### Bay-Delta Plan Brackish Tidal Marshes of Suisun Bay Narrative

The Bay-Delta Plan's narrative water quality objective for brackish tidal marsh protection is as follows:

Water quality sufficient to support a natural gradient on species composition and wildlife habitat characteristic of a brackish marsh throughout all elevations of the tidal marshes bordering Suisun Bay shall be maintained. Water quality conditions shall be maintained so that none of the following occurs: (a) loss of diversity; (b) conversion of brackish marsh to salt marsh; (c) for animals, decreased population abundance of those species vulnerable to increased mortality and loss of habitat from increased water salinity; or (d) for plants, significant reduction in stature or percent cover from increased water or soil salinity or other water quality parameters.

SWRCB determined, through modeling studies, that implementation of Bay-Delta Plan numeric objectives, particularly NDOI, would achieve the narrative objective. In the future, the Depart-

ment and the Bureau will review and replace the narrative objective with Suisun Marsh Ecological Workgroup recommendations.

### Western Delta Municipal and Industrial Users Agreements

Several contract water quality standards are in effect for western Delta municipal and industrial water users that predate D-1485 and subsequent water right decisions and plans. Under agreements with both municipal and industrial contractors, loss of offshore water is compensated for by substitute water supplies, net credit balances for days of above-average water, or monetary payment.

The Department contracted with the Contra Costa Water District in 1967 and with the City of Antioch in 1968 to ensure compensation for costs associated with the loss of usable offshore Delta water supplies resulting from SWP

operations. Credit for the number of days of above-average offshore water supplies of usable water quality is accrued to offset the number of below-average days in future years. CCWD's standard is for 142 days and Antioch is for 208

days of usable water. During the 1997-98 water year, a usable Delta water supply was available to CCWD and City of Antioch throughout the period of standard and no compensation payments were made.

## 6. Other Delta and SWP Reports

These additional reports, relating to 1998 operations, document Delta fish and wildlife studies, water quality conditions, water supply operations, and monitoring research. Some are published regularly and others are special one-time publications. For other Department titles consult Bulletin 170-98 for a listing of Departmental publications.

- (1) *State Water Project Operations Data Report*. Division of Operations and Maintenance's State Water Project Operations Control Office.

This report provides a monthly summary of operations data for the SWP and has been published monthly since 1965. It provides the State Water Contractors, public agencies, and others with the daily and monthly status of the Project's water and power operations. An electronic version is available at [www.wco.water.ca.gov](http://www.wco.water.ca.gov).

- (2) *State Water Project Annual Report of Operations 1992*, March 1998, Division of Operations and Maintenance's State Water Project Operations Control Office.

This annual report summarizes the water and energy operation of the SWP, includes historical data, summarizes the operation of project facilities during 1992, and includes any revision to data previously mentioned in the monthly report, *State Water Project Operations Data*.

3. *Bulletin 120-98, Water Conditions in California*, (Reports 1 through 4). Division of Flood Management.

This bulletin provides precipitation, snow-pack, and reservoir storage data throughout the State and is published as a set of four monthly reports (February through May). It is electronically accessible at [cdec.water.ca.gov/snow/bulletin120](http://cdec.water.ca.gov/snow/bulletin120).

- (4) *The North Bay Aqueduct Barker Slough Watershed, Water Quality Phase 1 Report*, July, 1998.

This report summarizes the first 12 months of the Municipal Water Quality Investigations Committee's follow-up activities in the North Bay Aqueduct Watershed.

- (5) *Methodology For Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh*, July 1998, Office of State Water Project Planning Delta Modeling Section.

This is the nineteenth annual progress report of the Department of Water Resources' San Francisco Bay-Delta Evaluation Program documenting the development and enhancement of Delta computer modeling efforts and reporting the latest findings of studies conducted.

- (6) *Municipal Water Quality Investigations Program 1997 Compendium of Water Quality Investigations in the Sacramento River Watershed, Sacramento-San Joaquin Delta, and San Francisco Bay Area*, August 1998, Division of Planning and Local Assistance.

This report presents 450 sampling sites in the Sacramento River watershed, Sacramento San Joaquin Delta, and the San Francisco Bay Area. These sites are sampled as part of 54 water quality programs conducted

by federal, State and local agencies. This report covers water quality programs and sampling sites of organizations that responded to an initial survey.

- (7) *Bulletin 160-98, California Water Plan*, November 1998.

In 1957, the Department of Water Resources published Bulletin 3, the *California Water Plan*. Bulletin 3 was followed by the Bulletin 160 series, published seven times between 1966 and 1998 to update the *California Water Plan*. Bulletin 160 assesses California's agricultural, environmental, and urban water needs and evaluates water supplies to quantify the gap between existing and forecasted water demands and the corresponding water supplies. This series presents a statewide overview of current water management activities and provides water managers and others with a framework for making water resources decisions.

The Department has participated in cooperative studies with other State and federal agencies and universities under the Interagency Ecological Program for the Sacramento-San Joaquin Estuary (IEP) since 1971. The following reports were published by the Department's Environ-

mental Services Office in 1998 and represent the results of scientific monitoring and field studies conducted in the Delta.

- (1) *Interagency Ecological Program for the Sacramento-San Joaquin Estuary*. IEP Newsletter, Volume 11, Number 1-4, 1998.

This multi-agency program newsletter reports the results of Delta water quality and fisheries projects, Suisun Marsh activities, and other scientific activities undertaken by the IEP member agencies, usually released as numbered technical reports.

- (2) *Interagency Ecological Program Technical Reports*.

Technical Report No. 56, *Report of the 1994 Entrapment Zone Study*, January 1998.

Technical Report No. 58, *Recommendations Regarding Comprehensive Aquatic Monitoring in the Sacramento-San Joaquin Estuary and Its Tributaries*, August 1998.

Technical Report No. 61, *Delta Agricultural Diversion Evaluation Summary Report 1993-1995*, June 1998.